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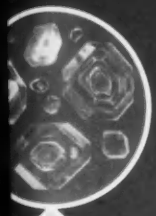

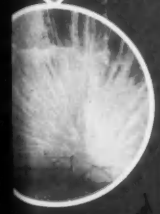

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Editorial:
Chemistry in High School
Inside Front Cover

PTEMBER
1958

50¢

irty-first Year

A SCIENCE SERVICE PUBLICATION

Chemistry in High School

➤ As one of the four active and traditional areas of secondary school science (the other fields being physics, biology and mathematics), chemistry plays an important role in preparation of youth for living in a modern world and advanced study in college.

The purpose of CHEMISTRY is to aid both teachers and students in keeping up-to-date and having contact with science, technology and industry beyond the confines of the textbooks and the class room.

In addition to summaries and reports of new developments in chemical science and technology, there are authoritative articles, new book notices, course-related material and curriculum supplements, career information, hints for the home laboratory, quotations and excerpts of significant speeches and papers, chemistry quiz, news of professional societies, together with photographs.

In this issue and subsequent ones, there are published some of the winning project reports of the Science Talent Search as examples of the inquiries and findings that can be done by students. Such material and lists of projects contained in the booklet, Thousands of Science Projects (25¢ postpaid from Science Service, Washington 6, D.C.) will be helpful to teachers and students who are selecting projects for science fairs and Science Talent Search. Such material will not be slavishly copied and repeated by competent and gifted students, but what others have done will inspire and suggest other, original projects.

CHEMISTRY

Vol. 32, No. 1 Formerly Chemistry Leaflet September, 1958

Including The Science Leaflet

Published monthly, September through April, by Science Service, Inc., the non-profit institution for the popularization of science. Publication Office: 326 W. Beaver Ave., State College, Pa. Entered as second-class matter at the Post Office, State College, Pa., under Act of Congress of March 3, 1879. Address subscriptions and editorial communications to the Editorial Office: 1719 N Street N.W., Washington 6, D. C.

$4 a Year; Two-Year Subscription $7; Your Own and a Gift Subscription $7 a Year.
50¢ a Copy. Ten or more subscriptions to the same address: $2.90 a Year each.
No charge for Foreign or Canadian Postage.

Editor: WATSON DAVIS **Assistant Editor:** S. DAVID PURSGLOVE

Consulting Editor: PAULINE BEERY MACK (Editor 1927-1944)

Editor in Memoriam: HELEN MILES DAVIS (1944-1957)

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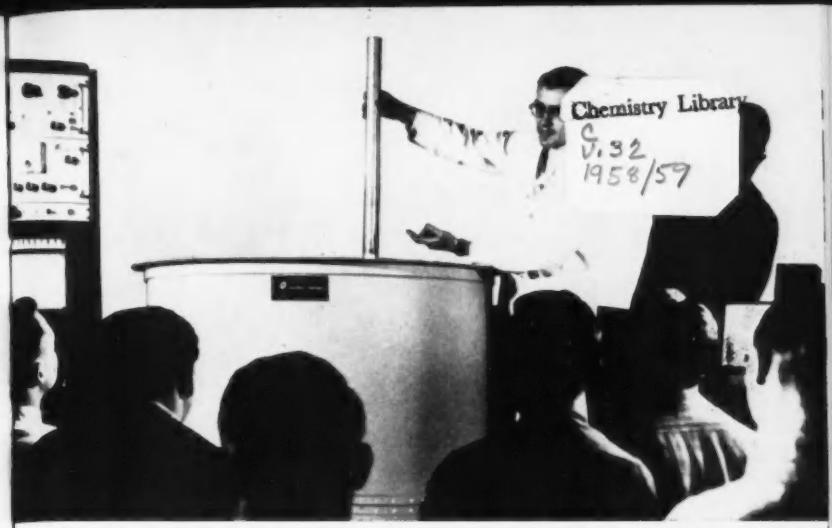
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▶ AN INSTRUCTOR *demonstrates to his class the operation of the "baby" subcritical atomic reactor developed by Nuclear-Chicago Corporation especially for educational and training use in colleges.*

Baby Nuclear Reactors

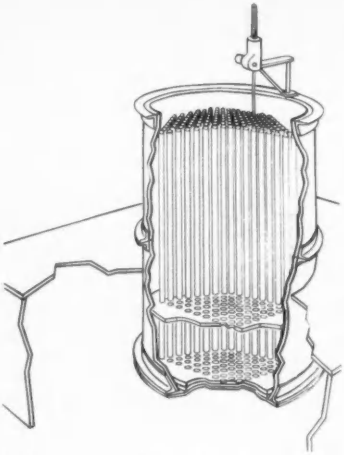
by NELSON M. GRIGGS

▶ TO RUN the atomic power plants of the future, colleges are teaching atomic energy, not just out of books, but by having baby atomic reactors in their laboratories.

These new machines are complete with uranium and a neutron source, but are what the scientists call "subcritical," that is, they are not self-energetic and "hot," as the bigger atomic furnaces that are "critical," and therefore are a sort of non-exploding atomic bomb.

In addition, the new baby reactors are obtainable for a fraction of the cost of even the cheapest critical reactor. The difference is that a separate neutron source is provided for the 'baby" as it does not contain enough atomic material to sustain a chain reaction by itself.

The move to make reactors available to colleges for purposes of education and training was instituted by the Atomic Energy Commission in September, 1956, as part of a program "to increase the supply of engineers, scientists, and technicians for the national atomic energy program and for the growing atomic energy industry." Lewis L. Strauss, then chairman of the AEC, said the purpose was two-fold: to "provide for direct financial assistance in securing equipment and teaching aids, and for a broadening of the Commission's existing program of assistance in the form of loans of certain materials."



➤ REACTOR *shown in a cut-away drawing.*

AEC Funds Used

The AEC policy has proved a boon to schools faced with growing student demands for atomic instruction in an atomic age but unable to afford reactors costing hundreds of thousands of dollars. Under the plan, the AEC makes funds available to schools for the purchase of reactors, provided the school can show the need for a reactor in a planned curriculum of educational projects, and also provided the school can guarantee funds for operating the equipment and conducting the required courses. In addition, atomic materials, which, under the law, cannot be owned by anyone but the AEC, will be furnished on a loan basis as reactor fuel.

Schools' Funds Also Needed

No funds, however, will be available for incidental costs such as for a new building to house the reactor, etc., nor will the AEC permit subsidized equipment to be used for commercial purposes.

The new baby reactor was designed especially for use in schools, and is manufactured by Nuclear-Chicago Corporation, Chicago, Ill. Company officials say that to date 50 schools have made application to the AEC for grants for atomic education programs, and the company in turn has made definite proposals to the schools at their request.

Most of these schools will be given the green light, CHEMISTRY learned, with the possible exception of one or two small liberal arts colleges that lack qualified staff members. Even these, however, will probably win limited grants for "pre-atomic" programs involving elementary equipment such as radiation sources, radiation counters, and the like. After a time, perhaps a year, when these schools can show capability improvement, grants for baby reactors will be allowed.

Nuclear-Chicago has received purchase orders for at least eight units to be delivered to colleges by this month for installation by the beginning of the 1958-59 school year. Most of the units are what the manufacturer calls "full packages" containing all necessary items and instrumentation for conducting a full atomic laboratory program.

Schools may buy the baby reactor in three price ranges:

1. Reactors alone, less accessories, $10,000.

2. Reactor with basic equipment such as platform, supports, plumbing fixtures, etc., $13,000.

3. Full reactor package, including all accessories and instruction manual, $30,000.

▶ A TYPICAL *student nuclear engineering laboratory. At the left background is a scintillation well counter and associated scaler and timer. On the same bench at the right is an automatic strip foil analyzer with count rate meter and recorder. An alpha survey meter and beta-gamma survey meter rest on top of the bench. At the left of the reactor a student surveys the area with a portable slow/fast neutron monitor, while behind him is an automatic gamma-ray recording spectrometer. At the reactor, students make measurements of neutron flux within the reactor lattice with* BF_3 *counters. At the right of the reactor, a student uses a scintillation detector in a manual sample changer. Beside him are two student counting systems consisting of simple scalers, manual sample changers, absorber sets, and timers. On the table in the foreground is a Cutie Pie survey meter.*

Although the above prices are approximate, based on the particular requirements of the individual college, they run pretty close to actual costs, a company spokesman said, and compare favorably with the least expensive critical reactor which costs in the neighborhood of $90,000.

Instrumentation contained in the "full package" consists of standard "catalog items," and accounts for approximately $17,000 of the package cost. Any school might already own some of these instruments, which would not need to be duplicated, leading to further savings both to the school and to the taxpayer.

Gain Industrial Experience

Such instruments are standard in industry and by working with them, students will gain knowledge and familiarity that will carry over into professional life. They include scintillation counters, Geiger counters, portable survey meters, and five- or six-student counter "set-ups," individual instrumentation combinations which enable more than one student to conduct laboratory experiments at one time. The package also includes a unique neutron counter that is placed directly in the heart of the reactor itself and indicates internal atomic activity by means of a remote meter. This device is exclusive with Nuclear-Chicago.

A feature of the package is the instruction manual. Individual instructors, perhaps at a loss to devise adequate training projects for individual students, will find a suggested curriculum outlined in the manual, from which he and the student may select appropriate experiments. The curriculum was carefully compiled from data supplied by university consultants, advanced engineering schools that had built their own subcritical reactors in the past, and from experiments in the manufacturer's own laboratories.

Professional opportunities for graduates in atomic energy are wide open, AEC officials say, and are not confined to the nuclear physics field. Not every student will go into industry to run a reactor. But graduates with a background of nuclear training will find open doors as chemists, biochemists, physicists, medical technicians, and many other positions where their knowledge of nuclear techniques is necessary to their working with radioactive materials.

➤ INSTRUCTOR *loads Student Subcritical Reactor with neutron source which is generally placed in the center of the uranium lattice. Source can be easily moved to bottom of reactor for special experiments. When installed in the reactor, the source presents no radiation hazard since it is shielded by both water and the uranium slugs.*

Radioisotope Use Increasing

Industry has been slow to make full use of radioactive isotopes. This hesitation is due to two factors: industrial executives have been reluctant to allow radioactive materials to enter their plants, fearing radiation injury to their workers; and, except in the largest plants, industrial firms lack personnel trained in the effective use of such materials. Manufacturers, however, can save money and make better products through the use of radioisotopes in analytical procedures by trained men who are familiar with such materials and their use.

Medicine on the other hand, is way ahead. Doctors can educate themselves in the techniques involved in isotope use through the reading of detailed published accounts of the results of experiments in laboratories all over the world. Through their associations with hospitals and clinics they have been practicing radioactive diagnostic and therapeutic techniques for many years.

The need today is for trained personnel in industrial research laboratories, both large and small. Because of the opportunities for unlimited research, university chemists and physicists usually tend to stay put, except to go with large corporations at substantial salary increases with equal research opportunities. Well-paid industrial nuclear engineering personnel can seldom be lured away from lucrative positions by smaller companies. The small business, therefore, must rely on the engineering graduate, of which there are all too few, or do without.

Starting salaries for the graduate accepting a position as a nuclear technician have been estimated at $5,000 to $6,000 per year, with advancement strictly a matter of personal accomplishment.

Through its progressive program of help to the school and encouragement to the student, the Atomic Energy Commission is indeed vigorously pursuing its "program of conducting, assisting, and fostering research and development in order to encourage maximum scientific and industrial progress" as charged by the Congress in the Atomic Energy Act of 1954. Farsighted manufacturers are cooperating to make the effort a reality by providing "baby" reactors for the classroom.

On the Back Cover

▸ First of its kind, *an educational atomic reactor which provides "microscopic" analysis of reactor phenomena is assembled by Rensselaer Polytechnic Institute faculty members at Troy, N. Y. The Atomic Energy Commission sponsored development of the reactor to establish a design and experimental procedures which might be useful in teaching reactor phenomena in colleges throughout the country.*

The R.P.I. installation, technically known as a subcritical uranium assembly, is a type of atomic reactor which has been widely useful because it does not contain sufficient uranium to become explosive. Its newly designed instruments will enable students to easily and safely measure changes in atomic phenomena brought about by changes in uranium arrangements or materials used, thus allowing them to take a closer look at phenomena underlying reactors. (See "Baby Nuclear Reactors," p. 1)

The unit and associated research cost about $250,000. Now the facility could be constructed for about $55,000, not including uranium costs. Left to right, faculty members are: Davut B. Ebeoglu, instructor in electrical engineering; Dr. Frank A. Valente, professor of physics; John N. Park, instructor in electrical engineering and Benjamin E. Chi, graduate assistant in physics.

Method Makes "Impossible" Materials

➤ METALS FORMERLY "impossible" to produce will be created by Air Force scientists who bombard objects with tiny high speed particles in much the same way micrometeorites from outer space smash into missile shells and satellite skins.

Through similar methods, the scientists will also produce revolutionary new materials and truly perfect vacuums.

One of the first investiations to be made by the new technique announced by the Air Research and Development Command will be the testing of missile and satellite coverings subjected to high speed particles bombardment.

However, the actual creation of alloys and compounds of incompatible materials is the major objective of Wright Air Development Center scientists who pioneered "micrometeorite bombardment" from their Dayton, Ohio, headquarters.

Officials cite as an example a possible alloy of aluminum and iridium.

Aluminum, which begins to boil away at 3,740 degrees Fahrenheit, cannot be combined as a liquid with iridium, which does not melt until it reaches 4,450 degrees.

Now, scientists using the new technique will pulverize the iridium to very small particles, probably about one 25-thousandth of an inch in diameter, and shoot them at extremely high speed into the tiny crevices in aluminum's lattice-like structure.

Thus, by shooting solid aluminum full of solid iridium, the impossibility of mixing the two in the molten state is no longer a barrier to an alloy that will have aluminum's desirable aircraft properties, yet have a much higher melting point for space-age use.

Micrometeorite bombardment will also be used to make long molecular chains of compounds composed of organic and non-organic substances, many of which could not be produced by previous methods.

Perfect vacuums that are needed before many laboratory studies can proceed further will be created by literally blasting out the last traces of air with high speed particles until a "hard" vacuum is produced.

Reactor Plant Can Withstand Explosions

➤ A NUCLEAR reactor plant of the Enrico Fermi fast breeder type can withstand an explosion equal in violence to that produced by 1,000 pounds of TNT a study at the U.S. Naval Ordnance Laboratory has shown. The plant will contain within its structure the shock waves developed in the air and in the sodium coolant and also fragments from the cylindrical covering materials surrounding the reactor core. The rotating shield plug, however, can be a serious hazard when projected by the gun action of the internal blast pressure in the reactor compartment, Drs. E. M. Fisher and W. R. Wise Jr. found.

Chemists Oppose A.M.A. Chemical Plan

▸ The American Medical Association's model legislation for control of hazardous substances has drawn heavy fire from the Manufacturing Chemists' Association.

The feature of the A.M.A. plan that drew heaviest criticism from Dr. Thomas W. Nale and Sanford J. Hill, representatives of the Washington, D.C., organization of chemical producers, is the "unfeasible" broad scope of regulation over chemical products designed for use in industry as well as in the home. They expressed their views before the A.M.A. Committee on Toxicology meeting in Chicago.

They contended it is one thing to label and regulate hazardous chemicals sold in small containers for wide use in homes by inexperienced persons, and quite another thing to regulate those same chemicals sold in bulk to a few trained industrial users.

The A.M.A. plan would attempt to control chemicals designed with both uses in mind through the same set of regulations and through a single agency, Dr. Nale and Mr. Hill pointed out.

They added that the A.M.A. model legislation "arises out of the 'great number of poisonings' in the household."

"While we are not convinced of the validity of the A.M.A.'s contention as to the number of poisonings due to the use of household chemicals, the safety record of chemicals used in industry has been excellent," they said.

The chemical spokesmen suggested that potentially dangerous household chemicals could be regulated through the Federal Food and Drug Administration, while another organization could be formed with entirely different objectives to oversee the industrial use of chemicals.

However, they stated they did not believe that "any case has been made for Federal legislation regulating the labeling of industrial chemicals at this time."

They pointed out that the M.C.A. has been active in the field of uniform precautionary labeling since 1944 and expressed "regret" that the chemists' group was not consulted before the doctors' organization formulated and distributed its plan.

The M.C.A. is actively supporting bills pending in Congress dealing with precautionary labels for household chemical products.

A background summary of labeling activities in recent years is available to teachers upon request to the Manufacturing Chemists' Association, 1625 I St., N.W., Washington 6, D.C.

A test facility has been developed which duplicates the intense heat encountered by missiles hurtling through earth's atmosphere at nearly 5,000 miles per hour.

Planes of the Strategic Air Command, on constant 24-hour global alert against aggression, use a railroad tank car of petroleum products per minute.

The Earth's Band May Be Electrons

➤ THE MYSTERIOUS band of radiation enveloping the earth, discovered by instruments carried in the satellites Explorers I and III, probably consists of electrons.

Electrons are tiny fundamental particles of matter, the smallest known having a negative electric charge. Electric currents are produced by mass movements of electrons in conducting materials.

The puzzling radiation could also include protons, the nuclei of hydrogen atoms and other atomic fragments with some of their electrons stripped off. These are the results of a preliminary examination of information radioed to earthbound listening posts from instruments in the Explorer IV.

They were reported by Carl E. McIlwain of the State University of Iowa, the physicist who developed the instruments especially for Explorer IV, and who is temporarily in charge of interpreting space radiation data.

His findings result from examining telemetered data from about 50 recorded completed orbits delivered to the Iowa decoding center.

The four radiation-detecting instruments in the new satellite are designed not to blank out under the intense radiation as previous equipment did. Their information has eliminated the theory that the mystery rays are X-rays created within the satellite when sun-spurted electrons bombard its metal skin.

The preliminary data show the orbiting instruments are speeding through an invisible rain of charged particles, probably electrons hitting the instruments directly, and possibly including protons or other atomic fragments minus their usual number of electrons.

At least 60% of these charged particles readily penetrate the one-sixteenth of an inch lead shielding each Geiger tube. How this intensity level might affect future space travelers is still to be determined.

However, at about 1,200 miles above South America, the radiation intensity is believed to represent an exposure level of about ten roentgens an hour. The roentgen is a unit of radiation dosage. The highest permissible exposure under current practice is three-tenths of a roentgen per week, so the space traveler might receive such a dose in about two minutes.

Aluminum and its fast-oxidizing alloys can now be soldered as readily as copper by using an ultrasonic soldering iron.

The possibility of an accidental nuclear explosion while transporting or storing nuclear weapons is so remote as to be negligible, according to the Atomic Energy Commission.

Argon gas, containing less than 50 parts per million of impurities, is now available commercially.

Scientists Needed in Important Posts in Business World

Science and Business

by Dr. Vannevar Bush

Chairman of the Board, Merck & Co., Inc., Rahway, N.J., and World War II director of the Office of Scientific Research and Development

(An address to the 10th Annual Rutgers University Business Conference, New Brunswick, N.J.)

▶ There are many ways in which science and business are related. All of us are aware of the use in business of the results of many scientific and technical activities. "Automation" has become a household word, even if few understand its meaning. It has also become fashionable in many corporate circles to talk of operational research activities and how these techniques can help management run a business.

By now it's well known that the scientific process can usefully be applied in thinking through many important management problems, and many programs of the American Management Association and similar organizations now emphasize that approach.

In addition, it has by now been recognized that scientists can themselves be pretty useful people in corporate work and that their experiences and backgrounds prepare many of them for all sorts of positions in the corporate world, even in the top management level where the highest quality of wisdom and judgment, not just technical training, are required.

After considering all sorts of such interesting variations on the theme "Science and Business", it seems to me it may be most useful if I trace some of my thoughts regarding the way in which scientific research activities can be most usefully fitted into a business organization.

Research Upswing

Since the war there has been a great wave of research in this country, occasioned in part, no doubt, by the spectacular sucess of the A-Bomb program, demonstrating spectacularly that scientific ideas, even of bizarre nature, can sometimes lead to practical results when adequately joined to applied research and engineering. Today, in industry, research is evidently producing results all about us. The Rockefeller Brothers report states that the rate of increase of national productivity, which was about 2% for generations, is now 3% and may be 4%. They paint a rosy picture of future prosperity if this latter figure is maintained, and a surprising picture if 5% should be achieved. Many factors enter into the size of this rate of growth, but there is no doubt that research, soundly applied, has a great deal to do with it.

In fact, it is well accepted today that an industrial unit in a changing technological field (and what field is not changing) must regard research as a necessity, and by no means as a luxury. And here is the rub. For not all research by any means yields sufficient results to pay its way, even in

the long run. There is no faster way to get rid of money than by ill-planned or ill-conducted research. Scientists are expensive, and becoming more so, and so are good engineers. Yet industry must have research to thrive in a rapidly altering technological world.

Business in this regard is in somewhat the fix that the whole race has been for some thousands of years. One half the race, notably the men can't get along, can't perpetuate the race, without the other half, and yet the attempts of the first half to manage the second half have been on the whole far from ideally successful.

Good Directors Are Scarce

There is no magic formula for fitting research into an industrial organization, no set of rules for managing research successfully.

Good research directors are scarce and hard to find. But I have a few thoughts that I think may help.

The prime criterion for operating successfully with research and with researchers, is to understand them. They are just a bit different from production men, or lawyers, or accountants, not better or worse, just different.

There are varieties of research.

First there is basic or fundamental research, sometimes erroneously called pure research. This is found principally in universities and endowed institutions, but there is some in government laboratories, and some in large industrial laboratories. Its presence in the latter is often highly advantageous, for it tends to lift the tone of the whole effort, and it helps in recruiting if there are nationally known scientists in the organization. American large industry has shown a great deal of wisdom in this regard, in encouraging the freedom of association with scientific societies and of publication, which is part of the university atmosphere, but which also renders an industrial laboratory attractive to creative minds. Well managed, a broad policy in this regard need furnish no improper aid to competition—quite the contrary.

There is no problem in managing fundamental researchers, for the simple reason that it is impossible to manage them, in the usual sense, by any means whatever. One can furnish the salaries and facilities, and aid their housekeeping, and that about ends it. To tell a fundamental scientist what to work on, or how to go about it, is just about as futile and disastrous as to try to tell your wife what to cook and how to cook it.

The progress of a fundamental research laboratory depends merely upon the calibre of the men and women in it, and the extent to which they like one another and collaborate. A good research director can help greatly on the latter point, but the way in which he accomplishes results is subtle indeed. I remember in this connection a remark once made by my great friend, Karl Compton. I saw a book by Dale Carnegie on his desk and chided him about it. His reply was that the art of making friends and influencing people consists in the total absence of art.

Three-Part Problem

But we are primarily concerned today with a different type of research, applied research, which seeks new knowledge, usually of a secondary scientific nature, and applies it to produce a new material, or device, or process. It leads directly to engi-

neering, where the matter of costs, and of economic considerations generally, enter. It is aimed positively at the attainment of useful results, and it is expected to pay its way, not every quarter, of course, but in the long run. Here there is a real problem of management, and a real opportunity.

This problem consists of three parts, first of having a smoothly operating group, with adequate well chosen facilities, good internal communications, and satisfactory housekeeping; second, a means for determining intelligently the subjects that are to be worked on; and third, an interrelation between groups so that projects which start at one end, in the form of an idea, become abandoned if proved abortive, and otherwise emerge from the other end reasonably promptly and in a form that is genuinely valuable.

I certainly do not need to dwell on the first point. This is not to say that its sound treatment is easy. I've seen laboratories with poor equipment. I've also seen laboratories so completely immersed in gadgetry and chrome plate that the staff spent most of their time fixing it. There are research establishments where everyone knows everything that happens that affects his job, and there are laboratories where the staff spends most of its time in meetings trying to find out. I've also seen groups that wouldn't talk to one another, except in formal memoranda. And I know of places where highly paid scientists worry about housekeeping details. But these are all elementary subjects, and they are common to business generally. So we will assume we are considering a well managed business, and that all these things are automatically well handled. If the business is not well managed the presence of research will merely hasten the inevitable.

The second point is much more interesting.

How is it decided what shall be worked on?

Is some master mind going to grasp the whole affair and dictate a program? Strangely enough I have seen this work surprisingly well for a time, but it is a miracle when it does. The most successful programs I know of do not get started that way. On the one hand there are the needs and opportunities of the business, on the other hand there are bright ideas. The problem is to marry the ones that will make congenial mates and bring forth healthy progeny.

The needs and opportunities are known by those who understand markets, the efforts of competitors, the trends in the industry, and above all production costs and sales opportunities.

The bright ideas are likely to appear anywhere in the organization, the most humble young researcher may have some of the best ones.

What is the means by which these two things are brought together, and the right combinations joined? This, I take it, is the main job of a research director. The title is a misnomer, he seldom directs anyone. He is nearer to a catalyst, and, in order to function, he should be so supported that his whole affair functions smoothly in its normal course when he leaves it alone. Moreover, he cannot do alone merely the job of furnishing the link between his group and the rest of the company, for the purpose

of ensuring that the research program makes sense in every particular. This has to occur throughout his organization, for conditions alter, partial results point out new paths, competitors also advance, and every research project hence needs to be under a continuous course of revolution and re-orientation.

Optimism Needed

The central point in establishing a research project is that it must be such that all concerned have enthusiasm regarding it. Management must be optimistic in regard to the potential value of the new results sought. The scientists of the research team, and the engineers for that matter, must regard it as worth doing because it presents an interesting intellectual challenge, because a successful handling of it will earn them respect in the eyes of their peers. It should not be forgotten that scientists, and professional men generally, do not put in intense efforts just to earn a good income. Beyond a point many of them care very little, really, for money and what it will do. They strive because they enjoy intellectual effort, and still more because they find their reward in the respect of those about them who are justly entitled to an opinion of their performance.

Hence, a sound research project should be one which two sorts of people concoct together, and which they both find attractive.

There is nothing worse, in my opinion, than the arbitrary assignment of jobs to a research organization. Certainly it has to be done at times, in an emergency, and if this is the exception rather than the rule the staff will respond loyally. But, in spite of the rare instances of success which can be cited, I hold that a dictated program is an anachronism. A research program should be a team effort, with the research staff an equal partner with the rest of the business. If research is put under production it will tend to become a fire department, rushing about to cure one production ill after another. A strong research group can be very embarrassing to production men who like to have all run smoothly and essentially unaltered, and it should be. If research is put under sales it will tend to produce monstrosities or trivialities, for salesmen have to sell currently and seldom take the long view. If research is left entirely free, without coordination, it will probably produce a beautiful structure, admired by the elect, which will not pay. These are exaggerations of course, there are broad wise individuals in all three groups I have mentioned. The point is they need to be brought together.

Sometimes whole large programs are imposed on an organization. This happens, for example, when a company takes a government contract for defense research. There is then very little chance to formulate, and, on the other hand, the judgment as to the value of potential results lies elsewhere. Still it is a mistake to enter on such a program unless the research staff agrees that the effort is worthwhile, and the program sound. There is genuine need, from a patriotic standpoint, for industry to collaborate in the research effort essential to national defense. But this does not mean that projects should be accepted blindly, even if they measure up from the point of view of fitting into the nor-

mal functioning of a company, and the contracts are so framed that the company can expect to come out somewhere even financially. The judgment as to the justification for carrying on the program, the estimate of the value of the potential results, cannot just be left to some military committee in Washington. Unless the company is admitted initially to confidence, and given the opportunity to form its own judgment as to values, unless the technical staff can genuinely collaborate with the military in formulating the program, it had better leave it alone. For no research staff ever produces to real advantage unless it considers it is doing something worthwhile.

Results Unpredictable

My third point is that there should be some organizational means present for ensuring that programs move, either toward a really valuable conclusion, or out, that they do not just drag along interminably. This is sometimes hard to do, and it takes real judgment and wisdom. One part of it is straightforward. There needs to be internal staff work on schedules. True, a research man on the fundamental parts of program can never tell just when he is going to get a result. In fact, he can't tell whether he is going to get one at all, or whether he may be surprised and find something quite unexpected, and possibly valuable in some other connection.

But there are other parts of a research program which are more routine, and these are properly scheduled. Several groups in a laboratory are needed to add their portion to the whole, special equipment needs to be made, design engineers need to enter at the proper point. And smooth staff work can help enormously to avoid annoying and expensive delays, peak accumulations which overburden sections, and all the other troubles which impede progress.

The tough problem comes on the other aspect of the subject—when to abandon a program. This involves more than just an occasional reconsideration of the probabilities of success on the one hand, and the value of a completed project on the other. It is safe to apply this when all the basic knowledge has been produced, and the rest of the job is just to polish things up and fit them together. But it is dangerous to apply it too rigorously when a scientist of real stature is still groping in the dark, searching for something which he thinks is there, following a trail and a hunch which are so subtle that he cannot explain them adequately even to his immediate associates. Out of such vagueness have often come the truly great advances, and scientists know it, and know that perseverance and patience often produce surprisingly. So it impairs morale to become arbitrary and to order a halt, even when it looks as though a competent individual butting his head against a stone wall. The cost of an unproductive effort is often less than the cost of loss of morale which comes from undue interference with individuality.

The answer, here, it seems to me, lies entirely in having such an atmosphere of mutual understanding and confidence within the laboratory, and between the laboratory and the rest of the business, that all such problems can be approached objectively, and without the emotional stress which distorts judgment.

So, I come back to my original thesis. The criterion for successful management of scientists and of scientific efforts is to understand them.

Happy is the company whose chief executives are respected by those in the ranks.

Twice happy is the company whose scientists and engineers feel that their boss is genuinely interested in what they are doing and how they do it, is striving to understand and to participate effectively in arriving at joint judgments where there is not the slightest sign of anything but real collaboration between professional men in adjacent fields, each respecting the special knowledge of the others, and each hence willing to give and take in an endeavor which requires for its success the contribution of all.

Ionic Pumps Create Better Vacuums

➤ BETTER VACUUM tubes for new electronic wonders are being made by vacuum "pumps" that do not pump.

Ultrahigh vacuums are being created by changing unwanted gases in vacuum tubes to solids instead of removing them.

These apparent paradoxes are common practice of scientists using new ionic vacuum pumps that create such nearly perfect vacuums that the tiny pressures often cannot be measured by existing instruments.

In a review of recent ultrahigh vacuum advances in the journal Science (Aug. 8), Dr. Lewis D. Hall, Varian Associates, Palo Alto, Calif., cited major advantages held by ionic pumps over older oil and mercury pumps used for many years to create the vacuums essential to electronics.

Most of the new "pumps," which actually are controlled electrical streams, involve no moving parts which must be adjusted or repaired. They eliminate pump fluids which sometimes contaminate vacuums. Ionic pumps do away with the necessity for bulky refrigeration equipment formerly used to maintain "cold traps."

Dr. Hall pointed out that usual definitions of the word "pumping" do not apply to the ionic pumps, but that scientists continue to call the devices "pumps" because they are capable of emptying a container of its gaseous contents.

Most of the pumps depend on the production of ions, or electrically charged particles, created when electrons are released from electrodes within the tube. The ionized gas particles then either combine with other materials in the tube to form a solid "fallout," become embedded in the tube walls, or are attracted to charged plates which confine them to a small area such that they no longer contaminate the vacuum.

Three air-drying coating systems have been developed for effective protection of magnesium alloys against high humidity-high temperature conditions encountered by high-speed aircraft.

Not more than 10% of high-purity silicon raw material eventually winds up in a useful semiconductor device; the rest is wasted.

Nuclear Rockets to Present Problems

▶ LAUNCHING of nuclear-powered intercontinental ballistic missiles and space rockets will involve the same type of radiation hazards as encountered in actual weapons tests, the joint Congressional Committee on Atomic Energy has been told.

Many radioactive fuel elements, probably in gaseous form, are expected to spew from the nozzles of nuclear rockets and contaminate the launching pads, Dr. Raemer Schreiber of the Los Alamos, N.M., Atomic Energy Commission testified.

For this reason, and because accidents could cause the reactor engines to "fall apart, not explode" and release all their fuel into the launching area, Dr. Schhreiber said it will be necessary to use launching pads "which you do not expect to use again for several months."

Such pads, he said, "can be located on centers that are not perhaps more than a half a mile apart, but you do have a problem of remote firing and of having a local contamination at the time of launching."

Such "blast-off" radiation will be much smaller than that encountered in tests of our smaller nuclear bombs, he said.

It is also possible, Dr. Schreiber told the Subcommittee on Outer Space Propulsion, that by the time we are ready to use nuclear engines in ICBM's and rockets, the reactors may have been perfected to a point where none of the radioactive fuel spews from the rear.

However, he stressed, there still will be the problem of neutron-activated steel, ground and concrete at the launch pads. It will take perhaps a few months "decay time" for this effect to wear off.

Need to Learn Math Early

▶ HIGH SCHOOL is the place for learning high school mathematics, not college, a U.S. Department of Health, Education and Welfare study shows.

And the skilled mathematics teacher is more important to a student's learning than either class size or various physical teaching devices.

Some 350 colleges participated in the survey of mathematics teaching summarized in an Office of Education bulletin written by Kenneth E. Brown.

Concerning the role of remedial programs in mathematics given in colleges, the report stressed that "no study shows that the college freshman receives, through a short remedial mathematics course, a desirable foundation in high school mathematics." One of the studies also showed a "most significant difference in pupil achievement under the various teachers in the experiment."

Copies of the 73-page report are available from the U.S. Government Printing Office, Washington 25, D.C., for 25 cents each.

Nuclear reactors cannot under any circumstances produce a bomb type of explosion.

New Magnet Will Broaden Research Fields

➤ SCIENTISTS soon will be able to get a better picture of what happens to materials at extremely low temperatures near absolute zero (459.6 degrees below zero Fahrenheit), thanks to the steady and reliable field of a powerful magnet installed at the University of California, Berkeley.

The new electromagnet is much more powerful than the huge magnets in the university's cyclotrons and bevatron, although many times smaller. Although its power is exceeded by several existing magnets, it has the advantage of maintaining a very steady magnetic field over long periods, whereas the fields produced by more powerful magnets can be maintained only for a few thousandths of a second.

For California chemists who will be using the magnet, these features add up to a tool unsurpassed in the world for making precise measurements of a magnetic field's effect on properties of materials.

Information about this effect, especially at extremely low temperatures, is vitally needed for advanced work on strategic electronic devices such as computers, missile guidance systems and radar-like detection devices.

Additionally, it will enable chemists and, particularly, plant-designing chemical engineers, to know the exact entropy or non-available energy locked up in materials. This lets them know how much energy to expect from various reactions and helps them determine when a reaction has been developed to theoretical perfection.

War Gas Antidote Perfected

➤ A NEW, protecting antidote for the nerve gas called sarin has been perfected.

While it has not been tested on humans, the new antidote has successfully blocked the lethal action of sarin in mice, a biochemist reported at the medicinal chemistry symposium of the American Chemical Society in Madison, Wis.

The antidote consists of a combination of PAD, pyridine-2-aldoxime dodeciodide, and the closely related PAM, pyridine-2-aldoximine methiodide, Dr. Irwin B. Wilson of Columbia University's College of Physicians and Surgeons said.

Nerve gases are lethal because they either paralyze the muscles that control breathing, or they attack the central nervous system, the associate professor said.

Administration of PAD and PAM to mice, before exposure to the gas, resulted in complete survival, while the use of either compound alone yielded almost no survivors, Dr. Wilson reported.

If the new combination successfully blocks the lethal effects of the gas in humans, it will greatly inhibit the use of sarin as a weapon.

In 1956 there was a $40,000,000 increase in aircraft losses from fire.

➤ VERNE DE HULCE, *16, of Lansing Mich., exhibited his nuclear magnetic resonance spectrometer at the National Science Fair, Flint Mich., in May, 1958. He won a National Science Fair first award and was designated a Navy Science Cruiser by the Department of Navy.*

Student Projects Build Scientists

by SHIRLEY MOORE

➤ PEOPLE who know very much about science fairs are not easily frightened by dour-faced prophets of democracy's scientific failure.

Anyone who has seen for himself what the younger generation is questioning and building and discovering cannot take these prophecies very seriously. Instead of dark pictures of second-rate doom, such people persist is seeing a vivid kaleidoscope of children and teen-agers working away at engrossing scientific projects.

Thousands of young students plan and develop projects in the summertime when school is out and there is

no pressure or incentive except their own driving joy in exploring and their private plans to enter the following year's science fairs, or the Science Talent Search for the Westinghouse Science Scholarships and Awards, or other scientific competitions.

This year nearly 40,000 students—87.5% more than last year—exhibited the results of their work in science fairs preliminary to regional fairs affiliated with the National Science Fair.

Scientific Detectives

Young people of all ages have taken to science projects as naturally as to any other kind of adventuring. They search the libraries, newspapers, scientific magazines and professional journals for the latest reports of significant research and challenging questions they might try to answer. As a matter of fact, they are such eager sleuths that adult scientists are often startled to find some of the frontiers of modern science rather competently mapped by young exhibitors at science fairs!

At this year's National Science Fair in Flint, Mich., for example, visitors could study graphically presented investigations of the new theory of the anti-universe, an ionic drive reaction motor, electroluminescence, and a method of producing oxygen from algae during space flight.

There were projects on solar energy and heat, and a solar motor; and another on cryogenics. Spectrographs, spectroscopes and spectrometers attracted the attention of visitors along with telescopes, a solar furnace, a cold chamber, an electron microscope and a polarographic analyzer.

Aerodynamics and weather study exhibits included a project on the upper air and one on seismology; an original sport plane; many on special problems of rockets, missiles and satellites; and even a model lunar colony.

Everything from stress, cancer and muscular dystrophy to the common cold and the action of tranquillizers was looked into by high school premedics. One student demonstrated tests of his theory of "Rhythm in the Id," in an attempt to show that rhythm can be learned during sleep.

The slide rule and electronics specialists had had a glorious time "automating" musical composition, tests of people's powers of logical analysis, typing and stenography, and the rapid solution of complex problems in propositional calculus.

Group and number theory, prime numbers, topology and many abstruse mathematical problems were taken apart and put together again by enthusiastic mathematicians. They seemed to have a special yen for tackling abstruse problems that are highly improbable for high school students; that is, by common educational standards.

Plastics and Insecticides

There were also such ingenious items as a frictionless spring, plastics made from gelatin and a lightweight concrete. Studies were presented on the effect of temperature on the action of insecticides; the control of Dutch elm disease and of bollworm infestation; on detergents and on the corrosion of steel; to mention just a handful of the outstanding projects on display at the fair.

Where do all these ideas come from? What is it that stirs up a young person's curiosity and imagination to the point that he is not only willing but determined to spend his after-school hours, weekends and summer vacations tracking down the answers?

To tabulate an accurate reply to this important question, Science Service asked the 281 finalists at the 1958 National Science Fair where they found the ideas for their winning projects.

Sources of Ideas

The largest number, 38%, said they discovered their basic "springboard" ideas in magazines, journals, newspapers and books. (One idea came from an advertisement and one from Science Talent Search literature.) Such reading was the source of almost twice as many inspirations as any other. This suggests immediate and relatively simple action that can be taken by parents, teachers, librarians and other people and organizations eager to encourage youthful scientific interest!

Personal observation of what goes on in the world, trips, hobbies, experiences, and imagination accounted for about a fifth of the project ideas. One student even "dreamed it one night."

Another 17% said their ideas came from school or from teachers and science club sponsors.

For 23 of the finalists, this year's exhibit was a continuation of long-term work or the outgrowth of former science experiments. Discussions with or advice from scientists, university professors or doctors started 18 projects.

Another 13 stemmed from science fairs or science congresses, meetings or programs. Families and family discussions inspired ten successful exhibits, and four finalists found their project ideas in jobs they had held in scientific fields.

Sources of Help

But who helps them? surely they can not do all this advanced work alone and without some expert guidance? Of course not. Like all good scientists, these students attempt to find out what already has been done in their particular fields, and they do need professional evaluation of some of their ideas and methods. This is where adult scientists, parents, teachers and other people with "know how" enter the picture.

There is, in fact, a gigantic "Project Protege" (as one such local activity was called) going on all over the country. Without publicity, and even without very much notice or appreciation from the rest of us, hundreds of highly competent specialists in industry, universities and laboratories are nuturing many of the embryo scientists of the next generation.

Uncounted hours of advice, pieces of hard-to-get equipment, unpublished reports have been made available to young students by busy scientists who often defer their own work or leisure to start a youngster on his way. Immeasurable enthusiasm and dedication have been exchanged in the process, to the mutual benefit of everyone involved.

This kind of incalculably important help is going on everywhere, from the office of a physician in an isolated rural community to the laboratories of world famous scientists and the

office of the President's Committee on Scientists and Engineers.

For example, this summer the President's Committee heard that National Science Fair finalist Joel Dressler, 15, of Arlington, Va., had wistfully complained that there was practically nobody he could taik to about his project on anti-matter. Understandably, most people begin to look dazed almost immediately and are able to think of very few appropriate comments or questions.

The Committee was able to make arrangements for Joel to visit the Atomic Energy Commission in Washington where he spent several hours talking to various experts, including Cmdr. Harry J. Watters who is entirely at home with the notion of an anti-universe. It turned out that Cmdr. Watters was gotten out of bed one night last spring to judge Joel's project at the Northern Virginia Scinece Fair, since no one on the Judging Committee felt qualified to score it.

Joel left the AEC with pamphlets and reports, and an invitation to come back often. Like other teen-agers, he intends to use his summer leisure to good advantage in continuing his project. Now, of course, he will be able to ask for advice if he finds himself boxed in by too many frustrating problems.

Famed Scientists Assist

The experience of Neil Nininger, 18, of Larkspur, Calif., under one of the University of California Radiation Laboratory's summer fellowships for promising high school students is an example of what the scientist-student relationship can produce.

A finalist at the National Science Fair in 1956, Neil met Dr. Glenn Seaborg when he appeared on a television program with the Nobelist that year. Dr. Seaborg was impressed by Neil's apparent ability and invited him to accept one of the fellowships at the Radiation Laboratory that summer. Neil carried out his assignment project so successfully that he was invited to return in 1957 and again this summer.

Another famous scientist, Dr. Edward Teller, "father of the H-bomb," chose Neil as one of five outstanding science students to take part in a series of television programs with him.

This year Neil entered the 17th Science Talent Search for the Westinghouse Science Scholarships and Awards, conducted by Science Clubs of America as an activity of Science Service. He won one of the top five scholarships and this fall will begin college training as a physical chemist of unusual promise. He was recently announced also as a winner of a National Metals Award in the competition conducted by the Future Scientists of America Foundation of the National Science Teachers Association.

It is scarcely necessary to comment that these are only two of many hundreds of equally promising pre-scientists, both boys and girls, who show every indication of developing their potential, given sufficient opportunity.

It is not difficult to understand, then, why adults who know about or work with these young people look toward the future with the most optomistic anticipation!

A Science Talent Search Project Report

A High School Radioisotopes Lab

by ALLAN PESTCOE
Miami Beach (Fla.) Senior High School *

➤ THE USE of radioisotopes in the high school provides a means for development of the techniques of experimental science in the high school student and a means for interesting students in general science.

The development of a high school radioisotopes program presents many difficulties, financially and educationally. I intend to deal here with a few of the difficulties and some of the rewards and objectives of the use of radioisotopes in the high school.

One of the primary difficulties in our program is the comparative lack of continuity in membership. A student may spend a period of from one to three years being trained and then must leave. Consequently a large part of one's efforts must be directed toward the training of new personnel.

➤ THE RELPAR *glove box in use. The glove ports have since been sealed with rubber iris diaphragms.*

There is probably no true solution to this problem.

The lack of general scientific experience on the part of the student is also a major obstacle. This is also one of the problems which the radioisotopes laboratory can help to alleviate. For, in the operation of a radioisotopes laboratory one is in new territory and the success of the laboratory depends upon a knowledge of many fields of science: electronics, metallurgy, biology, and general physics and chemistry.

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* *Allan Pestcoe was among the 40 winners of the 17th Annual Science Talent Search for the Westinghouse scholarships and awards. The paper reprinted here constituted only the introduction to his project which included descriptions of two series of experiments conducted in the radioisotopes laboratory. Other project reports from the Science Talent Search will be carried frequently in CHEMISTRY. Information about the Science Talent Search may be obtained from Science Service, 1719 N St., N.W., Washington 6, D.C.*

➤ THE LABORATORY *as of February, 1957. The photograph shows about half of the laboratory's total facilities.*

The rewards of a high school radioisotopes program are many. Primarily it provides a means of advancement beyond the realm of ordinary high school science. Also, it provides a means for the learning of experimental techniques through the process of actual practice.

I should now like to give some information on the laboratory of which I have been a member for four years, and director for the past year.

Since its inception in April of 1953, RELPAR (Radioisotopes Experimental Laboratory for Plant and Animal Research) has expanded from a dirt-filled plant garden to a fairly modern, well equipped radioisotopes laboratory. In usage of radioisotopes, the laboratory has grown from the use of a modest quantity of 10 microcuries to a yearly use of over 2000 microcuries.

In addition, the character of experimentation has substantially changed. Originally experimentation was almost solely concerned with plant nutrition. Since then, experiments have been conducted in a variety of scientific fields, including botany, animal physiology, chemistry, and physics. Various radioisotopes used include zinc-65, iodine-131, calcium-45, cobalt-60, rubidium-86, iron-59, and some uranium compounds.

Work now in progress or now being contemplated includes photosynthesis, thyroid studies in albino rats, and the construction of a linear accelerator.

The Florida Everglades is the largest peat and muck tract in the world.

√ *Chemistry Quiz* √

Directions: Mark within the parentheses corresponding to the answer you think is *most nearly correct*. Answers are on page 27.

1. Water is "hard" when it
   ( ) 1. contains acid in solution
   ( ) 2. contains certain dissolved salts
   ( ) 3. contains substances that precipitate soap
   ( ) 4. has small sand particles in suspension
2. The spectrograph is used for
   ( ) 1. making chemical analyses
   ( ) 2. measuring electrical impulses
   ( ) 3. recording shock waves
   ( ) 4. inducing an exothermic reaction
3. Which of the following is not an organic compound?
   ( ) 1. acetic acid
   ( ) 2. acetylene
   ( ) 3. disodium persulfate
   ( ) 4. benzyl acetamide
4. A cermet is a
   ( ) 1. gall found on cottonwood trees
   ( ) 2. metal-ceramic mixture
   ( ) 3. small rodent, native to India
   ( ) 4. unit of physical measurement
5. "Adiabatic" means occuring without loss of_____from the surroundings.
   ( ) 1. gas
   ( ) 2. heat
   ( ) 3. light
   ( ) 4. sound

Butyl Increases Sole Life

➤ LEATHER soles impregnated with butyl rubber and resins promise longer-wearing, water-resistant shoes for Navy men and civilians alike.

Shoes strengthened by the new development in sole leather have been wear-tested for more than three years, the Department of the Navy's Bureau of Supplies and Accounts reported. The impregnated sole leather outlasts conventional soles by 50%.

This development, Navy officials believe, represents the "most forward step in sole leather technology during the past half century."

Use of the leather, which is vegetable tanned, is expected to cause savings in shoe costs, less frequent shoe repairs, decreased producition time and less reliance on imported tannins, previously considered an essential in leather making.

Now being produced commercially by major sole leather tanneries, much of the new leather is being used to make children's shoes.

The sole leather was developed by the National Bureau of Standards in cooperation with the Navy.

Hawaii Student Rocketry Trial Urged

➤ HAWAII has been advocated as a proving ground for an experimental amateur rocketry program which would insure adequate leadership for student rocketeers and also provide retirement points for military reservists and National Guardsmen.

Sen. Edward J. Thye (R.-Minn.) urged Defense Secretary Neil McElroy to issue a directive which would allow reservists and Guardsmen to lead and instruct Hawaii's amateur rocketry groups as part of their military duties. Under the proposal, which Sen. Thye has twice before urged, the Guardsmen and reservists would receive commission and retirement points for their science youth activities.

The latest request, made from the floor of the Senate, was the first time Sen. Thye specifically urged that the reserve forces of Hawaii be a pilot group and that "we continue to watch Hawaii as an example that will materially affect our national survival."

He pointed out that a single directive issued by the Secretary of Defense would meet two pressing needs by supplying trained leadership to youngsters who need it, and by giving reservists and Guardsmen useful duties by which to earn credit.

The use of reservists in the nation's science youth effort was first proposed publicly by Kendall K. Hoyt, executive director, Association of Missile and Rocket Industries, Washington, in an exclusive Science Service interview last March. (See March, 1958, CHEMISTRY, p. 16.)

The plan was presented to Sen. Thye by Mr. Hoyt and Lt. Col. Charles M. Parkin Jr., Army Corps of Engineers, Fort Belvoir, Va.

Army Science Shown to Young Scientists

➤ SIX HIGH SCHOOL scientists have been exploring the newest frontiers in science on recent trips to U.S. Army installations.

Chosen by Department of the Army judges as winners of the U.S. Army Science Awards at the Ninth National Science Fair, conducted by Science Service in May at Flint, Mich., were: William A. Dunson, 16, of Atlanta, Ga., Alden H. A. Fairburn, 17, of Loraine, Ohio, and Paul E. Webb Jr., 16, of Hampton, Va. Last week they were flown to Walter Reed Army Medical Center, the Jet Propulsion Laboratories in Pasadena, Calif., and to the Army Ordnance Missile Command in Huntsville, Ala., respectively.

In each case, the student spent two days at the installation as a guest of the Department of the Army and was given unusual opportunities to observe and discuss scientific work currently in progress.

Three alternate winners were also chosen at the National Science Fair. However, their projects were considered to be so outstanding that science trips were awarded to them as well.

A New Feature Of CHEMISTRY

The Chemical Organizations

by DAVID PURSGLOVE

➤ CHEMISTS ARE represented by a wide variety of professional societies, each serving a different facet of a chemist's interest. Dozens of trade groups and associations serve the industry that employs chemists.

The chemist who does not belong to one or more of his professional societies not only cheats himself of a rewarding and almost necessary experience, but he also cheats the profession that supports his physical and intellectual existence.

The chemist has everything to gain from *active* membership in a professional society, but in turn it is his responsibility to support the society and contribute to its growth. As his society grows in size and stature, so grows the active member in knowledge and ability.

Likewise, the business firms producing or using chemicals — and today that includes nearly every industrial concern, one way or another — benefit individually from their united efforts to improve the industry and its many specialized segments.

Here, too, do we find truth in saying that one gets out of an organization only what he puts into it. The large number of active, well established organizations representing various chemical interests indicates the value of such groups.

As an aid to teachers seeking reliable information about chemistry as a profession and the chemical industries as career fields, and as an aid to students who some day will be active in the professional societies and perhaps conduct research for members of the trade associations, CHEMISTRY will print each month a summary of activities conducted by organizations representing chemistry's people and businesses.

The descriptions presented here are those of the American Chemical Society as a chemists' professional society, and the Manufacturing Chemists' Association as a representative of the industry.

The descriptions have been written by staff members of the groups.

American Chemical Society

➤ ALTHOUGH often referred to simply as the ACS, the American Chemical Society is the largest, oldest and best known scientific and professional organization in the field of chemistry and chemical engineering in the country. The ACS is the world's largest organization devoted to a single science.

Its membership of over 85,000 is distributed mainly among 155 local sections which include a large portion of the geographic area of the United States and its possessions. The ACS is dedicated to the advancement of chemistry in all its branches, to the improvement of the qualifications and contributions of chemists, and to

the dissemination of chemical knowledge.

Subject Matter Divisions

The ACS has 22 divisions which have no geographic boundaries but which are organized on the basis of subject matter interest; for example, analytical, organic, chemical education, petroleum, etc. The ACS arranges two national meetings each year at which about 3,000 scientific papers are read and as many as 20,000 members may attend. In addition, local sections arrange nearly 2,000 local meetings annually and the various divisions sponsor others. These meetings give members opportunities to broaden professional contacts and to obtain new viewpoints on scientific and professional matters.

In this scientific age when literally thousands of scientists are continuously adding to our storehouse of chemical knowledge it is essential that new facts, new research methods, and new theories be published and disseminated as widely and quickly as possible. The ACS meets this scientific obligation by the publication of its highly regarded journals — *Journal of the American Chemical Society, Chemical Abstracts, The Journal of Physical Chemistry, The Journal of Organic Chemistry, Industrial and Engineering Chemistry, Analytical Chemistry, Journal of Agricultural and Food Chemistry* and *Chemical and Engineering News*. The ACS also participates in the publication of a number of review books and treatises on special chemical topics. The Division of Chemical Education publishes *The Journal of Chemical Education* which is of special interest to chemistry teachers in both high schools and colleges.

Student Activity

The ACS is actively interested in the scientific and professional development of students — the chemists and chemical engineers of tomorrow. In addition to the student affiliate and student member programs in colleges and universities, many local sections of the ACS offer a variety of services to high school chemistry teachers and their students. Career guidance information, lectures, assistance with laboratory demonstrations and experiments, assistance with science fairs and science projects, awards to teachers and students, movies, scholarships and help in locating needed equipment are among the aids to high schools offered by various local sections. Information on the availability of this cooperative assistance may be obtained from local section officers or from the national headquarters of the American Chemical Society, 1155 Sixteenth Street, N. W., Washington 6, D. C.

Manufacturing Chemists' Association

➤ The Manufacturing Chemists' Association, established in 1872, is the oldest chemical industry trade organization in the United States. Its approximately 170 members — all manufacturers and sellers of chemicals and chemical products — comprise more than 90 per cent of the nation's chemical production capacity.

The size of these member companies and the products they make are varied as chemistry itself. Approximately one-half of the membership comes under the category of

small business as defined by the U. S. Department of Commerce.

Although many of the Association's members are in direct competition with each other, the MCA provides a channel through which they can deal constructively with common industry-wide problems. The organization is engaged in about 35 basic activities with 22 technical and functional committees assisting in the implementation of specific programs.

Fields of Interest

The areas of operation include safety, education, air and water pollution abatement, traffic, transportation, packaging, precautionary labeling, plastics-in-building, trade and tariffs, industrial relations, public relations, regulations and legislation.

These and other activities handled through the Association are initiated by committees composed of industry specialists, who serve without compensation, and are coordinated by staff secretaries. The MCA's Washington headquarters has a staff of 48 persons, headed by a full-time president.

The Association sponsors a number of workshops, conferences, symposia and meetings throughout the year. Its publications include more than 150 pieces of technical literature, a pamphlet entitled *"The MCA—What It Is, What It Does,"* and *"Chemical News"*, a widely distributed bi-monthly designed primarily to bring news and features from the chemical industry to students and laymen.

Education Program

The MCA has received great response and commendation for its aid-to-education program during the past two years. This continuing project includes supplementary materials for general science students, 31 "open-end" experiments for senior high school chemistry students, and teacher aids — all furnished on request to schools throughout the nation. In addition, the Association recently completed the first of a series of motion pictures, one on "Combustion" and the other on "Chlorine."

The MCA's College Chemistry Teacher Awards program recognizes and rewards outstanding chemistry teachers. Six awards each of $1,000, a medal and a citation are presented.

Fundamental research is sponsored by the Association at Carnegie Institute of Technology, Massachusetts Institute of Technology and The Academy of Natural Sciences of Philadelphia.

In 1958 the MCA launched its Chemical Industry Activity Committees in plant communities. This program is designed to assist local industry personnel in their community relations endeavor, including assistance to schools and civic groups, and to better explain the industry to all.

The Manufacturing Chemists' Association is located at 1625 I St., N.W., Washington 6, D.C.

Answers to CHEMISTRY QUIZ on page 23.
1, 2; 2, 1; 3, 3; 4, 2; 5, 2.

U.S. Self-Sufficient Only in Mg, Mo

➤ THE U.S. is truly "self-sufficient" only in magnesium and molybdenum out of the 32 vital minerals.

The greatest contribution of engineers, therefore, is to do nothing that will further drain our natural resources, Rear Adm. H. G. Rickover, assistant chief of the Navy's Bureau of Ships for nuclear propulsion, suggested at Hoboken, N.J.

He told young engineers graduating from Stevens Institute of Technology the U.S. is no longer one of the world's richest countries in mineral and fuel resources. Adm. Rickover, who is also chief of the Atomic Energy Commission's naval reactors branch, said this country is now importing many vitally needed materials, whereas it was once a great exporter of raw materials.

This change occurred in the last 25 years and should be taken into account by the engineer in his planning. Adm Rickover cited an example concerned with building a bridge across a body of sea water with valuable oyster beds. The selected location ruined the beds, but a small change of location would have saved them and the livelihood of many persons.

"Engineers," Adm. Rickover said, "build structures which alter man's supply of pure air and water, of food and soil.

"A poorly designed factory may poison air and water; a dam or highway may needlessly rob our grandchildren of good farm land which by then may well be in short supply.

"Almost everything the engineer does has an effect on our materials base. His work is seldom purely an engineering task, though he sometimes acts as if it were."

Adm. Rickover urged that consultation with other experts by engineers become as common as it is among doctors.

He suggested that each graduate do his work in such a way that he would always leave the country "not less but better than" he found it.

Russia to Emphasize Plastics

➤ RUSSIAN PLASTICS production will expand 10 to 20 times what it is today during the next five or six years, a Gordon Research Conference of the American Association for the Advancement of Science was told at New London, N.H. Dr. S. E. Bresler, Institute of Macromolecular Compounds, Leningrad, admitted that present production in the U.S.S.R. is limited and production of some plastics is adequate only for commercial uses and not for a consumer market. One objective of the huge expansion program is to make a wide variety of plastics plentiful for consumers.

By tagging substances with radioactive phosphorus, researchers are tracing the compounds through complex chemical and biological changes in the body for clues to the origin of mental disease.

Missiles can wear out simply by standing idle.

Chemical Understanding Aided By Nuclear Physics Research

Mining the Cores of Atoms

by ANN EWING

A NURSERY RHYME answers the questions: "What are little girls made of?" (Sugar and spice, and everything nice.) and, "What are little boys made of?" (Snips and snails, and puppy-dogs' tails.)

But scientists have to find out for themselves: "What is matter made of?"

The Greeks thought they had the answer and invented the word "atom" to indicate the ultimate particle, one that cannot be cut up. Now it is known that the atom can be divided, so it is defined as the smallest building block of chemical elements.

Although an atom cannot be broken up by chemical means, it can be smashed apart by other atoms or by particles, and some atoms decay or break up spontaneously, continuously emitting radiation.

Atomic Structure

Basically the atom consists of a nucleus, containing neutrons and protons, around which swarms a mist of one or more electrons, swirling around the nucleus millions upon millions of times each second. The nucleus, or central core, holds most of an atom's mass.

Scientists exploring the strange behavior of the tightly packed nucleus are now beginning to make some sense of their discoveries and to recognize an orderly arrangement in the bewildering number of particles found there.

The past two years have brought great progress in nuclear physics—the disproval of the parity theory that an object or system cannot be distinguished from its mirror twin, and a firm foundation for understanding both theoretically and experimentally the so-called weak interactions.

Even more progress in nuclear physics is expected in the near future. An ultimate result of such research may be harnessing nuclear forces for peaceful power purposes.

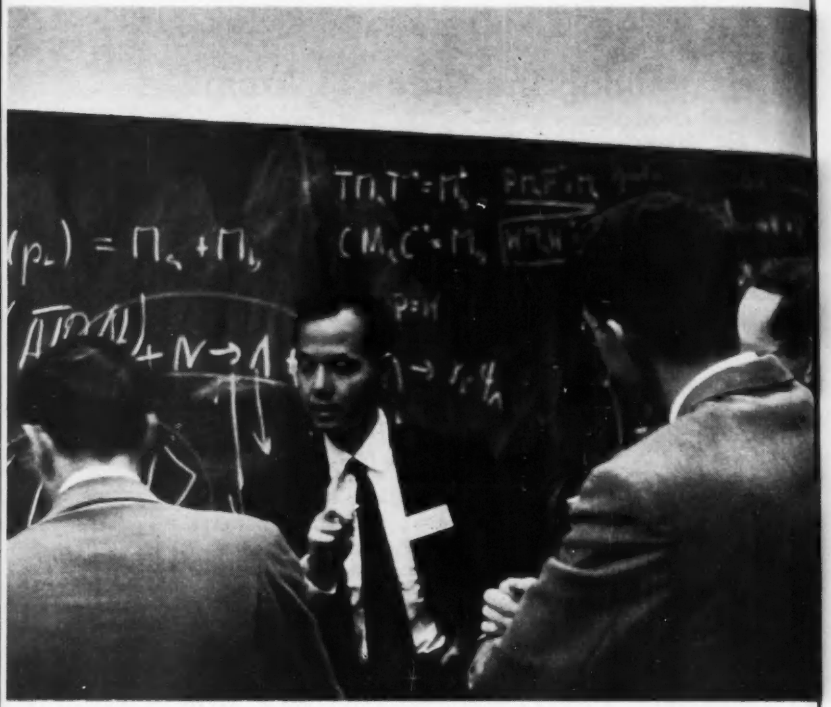
Order from Chaos

At this time, however, the reason most scientists are probing the mysteries of atomic nuclei is for the intellectual adventure of it: the possibility of bringing order and understanding where once there was only seeming chaos.

Scientists are now taking the nucleus apart the way they once took atoms apart. They are finding there are certain similarities in their structures.

The atom has a cloud of electrons circling the nucleus. The nucleus itself, however, does not have a sharp edge. It is, rather, like a ball of yarn with a very fuzzy edge, believed caused by a cloud of mesons.

Another similarity is the suggestion that both atoms and nuclei have a shell-like structure. The laws of atom formation, as they are now understood, prevent two electrons from circulating in the same orbit at the



➤ To communicate their *latest ideas concerning the structure of the nucleus, scientists find chalk, a blackboard (and eraser) indispensable. Here Dr. T. D. Lee of Columbia University, co-winner of the 1957 Nobel Prize in Physics, discusses his most recent theories with colleagues at the 1958 International Conference on High Energy Physics at Geneva.*

same time, unless they spin in opposite directions.

More than two electrons cannot share an orbit at all, and the number of orbits that can occupy the space a certain distance from the nucleus is strictly limited. Each group of orbits may be thought of as comprising a "shell" at a certain distance around the nucleus.

Magic Numbers

The chemical properties of the elements depend upon the number of electrons filling the possible orbits. When the outermost orbits contain 2,8,8,18,18 and 32 electrons, the shells are filled

There appears to be a "magic number" corresponding to a similar "closed shell" inside the nucleus.

Based on the amount of energy required to knock the last neutron from a nucleus, scientists have found that nuclei with 20, 50, 82 or 126 neutrons or protons are particularly stable.

Picture analogies in subnuclear realms are not exact, and are far from satisfactory. The atom's inhabitants must be described simultaneously as both waves and particles, and it is impossible to be certain where they are at a definite moment. Yet the picture of the "closed shell" is useful if it is not taken too literally.

Various models of nuclei have been proposed to explain their interactions and reactions. One, the optical model, is known as the "cloudy crystal ball," so-called because when fragments of atoms are hurled at nuclei in giant atom smashers, the resulting pattern is similar to the diffraction and absorption of light by a cloudy crystal ball.

Another model, particularly applicable to the nuclei of heavy elements in which many particles are crowded together, as in radium, is like that of an unstable water drop. When such a nucleus is hit with a bombarding particle, the particle is temporarily absorbed. After an extremely short time, measured in billionths of a second, a particle is emitted, or sometimes the nucleus splits in two.

Although billionths of a second seems like a very short time, it is much longer than physicists would expect on the basis of their theories. Such events unaccountably take about ten billion times longer than would be expected. The reason for this time lag is still a puzzle.

Within the past two years, however, two puzzles have been solved.

It is now known that parity is not conserved in weak interactions. Before the disproval of this long-held idea concerning the symmetry of space, scientists had thought the mirror image of a nuclear reaction was identical with the reaction. Now they know this is no longer true.

The two physicists who suggested that parity might not be conserved, Dr. C. N. Yang of the Institute for Advanced Study, Princeton, N.J., and Dr T. D. Lee of Columbia University, won the 1957 Nobel Prize in Physics for their work.

The other puzzle now understood is the theory of weak interactions of nuclear particles. This understanding, on a firm foundation both theoretically and experimentally, gives scientists a new tool to use as a probe for strong reactions.

The universal theory of weak interactions was first proposed by Drs. Robert Marshak and E. C. G. Sudarshan of the University of Rochester, N.Y., and independently by Drs. Richard P. Feynman and M. Gell-Mann of California Institute of Technology.

Some of the remaining problems are expected to yield to solution through use of the new dispersion relations, which are made possible because weak interactions are now understood.

Nuclear Family Listed

There are now 30 inhabitants of atomic nuclei known. Dr. J. Robert Oppenheimer, director of the Institute for Advanced Study, has constructed the following list of them:

The long-known electron, proton and neutron, and their more recently discovered electrically opposite counterparts, or antiparticles.

Three weightless particles, the light quanta, and the neutrino and anti-neutrino.

The mesons, consisting of a pair, a triplet and a quadruplet, having a mass several hundred times that of the electron.

The hyperons, a pair, a quadruplet and a sextuplet, heavier than the proton.

No new particles have been added to the list in more than a year.

The neutrons and protons making up the nucleus are held together by a mysterious glue called the nuclear force. It is neither gravitational nor electric in nature, and physicists are struggling to determine exactly what it is.

Smallest Energy Unit Found

➤ THE SMALLEST indivisible unit, or quantum of energy, required to produce turbulence in rotating liquid helium has been detected for the first time.

It was discovered by Dr. W. F. Vinen of the Royal Society Mond Laboratory, University of Cambridge, England. He reported his method for spotting it in the British scientific journal Nature.

Liquid helium is of particular interest to physicists because it is a substance that shows some quantum behavior on a large scale when it is cooled down to within about a degree of absolute zero, which is 459.7 degrees below zero Fahrenheit.

Other known quantum characteristics occur on the atomic scale where effects cannot be measured on an individual atom.

Dr. Vinen measured the circulation around a fine wire placed in rotating helium to obtain the first direct evidence for the quantum of circulation. He also studied the peculiar flow pattern of the very cold liquid.

Heat-Resistant Aircraft Tires

➤ AIRCRAFT TIRES that are not affected by the high temperatures of supersonic flights are now being made from a new type of synthetic rubber, George M. Konkle, Dow Corning Corporation, Midland, Mich., reported. The heat-proof tires are made of silicone rubber that can be molded and extruded on the same equipment used for natural rubber.

Slow Readers May Be Scientists

➤ SLOW READERS may end up at the head of the class instead of in the dunce corner, at least in science and mathematics classes.

The superior achievement of slow and careful readers of science, mathematics and other difficult text was revealed here by Dr. Arthur E. Traxler, executive director of the Educational Records Bureau. He recommended that children should be taught early to adjust reading speed to types of material.

For The Home Lab:

Benzene

by Burton L. Hawk

▶ In the so-called "good" old days, illuminating gas was prepared by allowing whale oil to drop onto a red hot furnace. The flamable gas thus formed was compressed, stored, and eventually delivered to the consumer. When the gas was compressed some liquid was obtained with it. In 1825, Faraday investigated this liquid and finally obtained a hydrocarbon from it which he called "bicarburet of hydrogen". Thus the compound benzene found its way into the world and I suppose we can credit Faraday as the first person to prepare it. The same compound was prepared in 1834 by Mitscherlich. He obtained it by distilling a mixture of benzoic acid and lime. And still later, in 1845, Hofmann isolated the compound from coal tar.

Sometimes benzene is also known as "benzol". However, since "ol" has been used for quite some time to denote an alcohol or a phenol this name is not correct. So you must always remember to refer to benzol as "benzene". Also, do not confuse benzene with *benzine* which is an entirely different product obtained from petroleum fractions, although the two compounds are pronounced the same. This is done in order to confuse students and hence keep them from being bored.

Preparation

Benzene is so abundant and inexpensive, it certainly is not practical to prepare it in the home laboratory. However, a small quantity of it can be prepared strictly for demonstration purposes — or to pass the time away, if you have nothing better to do.

Mix thoroughly together small quantities of benzoic acid and soda lime in equal portions. Transfer to a dry test tube and apply heat, being careful not to scorch the powders. Remove from the flame and smell cautiously at the mouth of the tube. Can you recognize the odor of benzene?

If you desire to prepare a visible quantity of benzene, it is best to approach the situation by a different method. In an evaporating dish, dissolve 5 grams of sodium hydroxide in 15cc. of water by gently warming the solution. Then add 6 grams of benzoic acid, stirring constantly. With continued stirring, evaporate the solution to dryness. You now have an intimate mixture of sodium benzoate and sodium hydroxide. Grind this mixture to a fine powder and transfer it to a dry test tube. Clamp the test tube on a ring stand in an inclined position with the mouth slightly lower than the closed end. Insert a one-hole stopper and glass tubing which leads downward into another tube which is immersed in a container of ice water. Apply heat to the test tube. Keep the flame constantly moving in order to avoid scorching the powders. Benzene will distill over and condense in the receiving tube.

Properties

Before we proceed further, we must pause for a word of caution.

First, benzene is highly flammable. Guard against fire while working with it. Second, the vapors are toxic. Do not inhale and work in well ventilated surroundings. And finally, benzene is readily absorbed through the skin. Avoid spilling on the hands.

Place one cc.—*no more*—of benzene in a metal lid and ignite with a match. Notice the smoky flame. With a tongs, grasp a porcelain crucible lid and thrust it in the flame. Note how quickly the white porcelain is covered with a layer of black carbon.

You can freeze benzene as well as burning it. Place again one or two cc. in a small test tube. Insert the tube in a container of cracked ice, salt, and water. After a short time remove the tube. The benzene will have frozen solid, as you can determine by inverting the tube.

Benzene is an excellent solvent. Drop a few iodine crystals in some benzene. Note the crystals dissolve to form a lovely purple solution. Place a small piece of paraffin wax in a tube containing benzene. Upon stirring with a glass rod, the paraffin will dissolve. You can try dissolving grease, cottonseed oil, rubber, and similar items.

Nitration

In a test tube, pour 1 cc. of concentrated nitric acid. Add a few drops of benzene and stir thoroughly. Then add slowly 1 cc. of concentrated sulfuric acid. Stir again and allow to cool. Pour the solution into a beaker of cold water and stir again. Note the heavy yellow oil that separates out in droplets. This is *nitrobenzene*. It has an almond-like odor.

Several compounds are formed by the nitration of benzene. Here is another one. Mix 1 cc. of concentrated nitric acid with 2 cc. of concentrated sulfuric acid in a test tube. Add three drops of benzene and carefuly heat to boiling for 30 seconds. After cooling, pour the liquid slowly into 15 cc. of water in another tube and shake well. A copious yellow precipitate is formed. Filter it off, wash it thoroughly, and place it in a solution of 4 cc. alcohol and 4 cc. water. Heat the solution until the precipitate is entirely dissolved. Pour the solution in a watch glass and allow it to evaporate. A mass of long needle-like crystals will remain. This is *m*-dinitrobenzene.

Sulfonation

Benzene does not react with sulfuric acid in the cold. But if heat is applied, a sulfonation reaction occurs. Add 1 cc. of benzene to 4 cc. of concentrated sulfuric acid in a test tube. Note the liquids do not mix. Now insert a rubber stopper in the tube which contains a piece of glass tubing about 3 feet in length. This tube will serve as a reflux condenser. Apply gentle heat to the test tube and allow the mixture to boil gently for about 5 minutes, after which time the benzene should be completely dissolved. Pour the liquid into a beaker of water and stir. Note the benzene no longer separates out. It has been converted to benzenesulfonic acid which is soluble in water.

We need not stress the importance of benzene. Besides an important solvent in itself, benzene is even more valuable as a starting point in the preparation of many organic chemicals used in medicine, dyes, varnishes, lacquers, linoleum, and numerous other articles.

Glues May Replace Nails and Rivets

➤ ONE DROP of glue was recently used to join two pieces of steel rod together. Held together for 20 seconds, with no more pressure than that of a man's hand, the glued-up rod was used 30 minutes later to hoist a car and four people off the ground — a 5,000-pound load.

This remarkable feat, reported by the Manufacturing Chemists' Association's *Chemical News,* was made possible by chemical research into the mysteries of adhesion. From this research has come a variety of new glues with an almost bewildering array of capabilities. Many of these new adhesives, made from epoxy resins, are often referred to as epoxies. Plastic in nature, they link the molecules of the adhesive with those of the material being bonded.

Today these super adhesives are being used in supersonic jet craft and missiles as a replacement for rivets on windstream surfaces. Yet they maintain full strength at the 500 degree and over temperatures created by supersonic flight. But their unusual uses do not end here.

When cracks showed up in a concrete abutment of the Golden Gate Bridge, engineers used an epoxy resin adhesive to repair them. Prefabricated concrete roadside curbs are now being glued into place, thus eliminating the time and expense involved in pouring concrete and making forms at the road site.

One of the most curious of these new, tenacious bonding agents is a blackish putty, 80 per cent powdered steel, 20 per cent epoxy resin. A catalyzing chemical quickly reacts with the resin to form a stubborn bond which not only joins materials together but also joins together the steel particles of the putty which, in effect, become solid steel, capable of being machined like the metal itself. Patching holes in radiators or filling holes in castings are just a few uses.

Still other adhesives, though not quite as dramatic as the epoxies, are performing many formerly undreamed of jobs. Asbestos shingles can now be glued into place far more effectively than they can be nailed. Coating the lower side of these shingles is a petroleum-based adhesive that sets under the sun's rays secures them even against high winds. For inside work, synthetic rubber-based adhesives are being used on vinyl floor tile. Stripped of its protective paper backing, the tile need only be pressed into place. Wallpaper, coated with a pressure-sensitive backing, can also be pressed into place.

Another of these curious but tough adhesives looks like kerosene. It works its way into the threads of nuts and bolts, where cut off from air it reacts with the metal to form a tight bond.

With new uses being found for the glues, tomorrow's house may be glued together rather than nailed.

If it proves ultimately possible to construct a power station operating on the fusion of deuterium, the oceans of the world will provide a virtually inexhaustible source of fuel.

Chromium Cancer Bullets

➤ CANCER-FIGHTING radioactive "bullets" have been developed by Bureau of Mines scientists.

The "bullets", designed to be either "shot" or implanted into cancerous tissue, are actually small metal cylinders cut from fine strands of high-purity chromium wire produced only at the Bureau's Northwest Electrodevelopment Laboratory, Albany, Ore. They measure a tenth of an inch in length and are a thirtieth of an inch in diameter.

The chromium "bullets" are exposed to neutrons in a nuclear reactor and made radioactive so they emit gamma rays in the manner of radium.

The radioactive chromium-51 cancer-fighting has already been used in animal experiments and results of work by Dr. William G. Myers of the Ohio State University Health Center indicate that it may prove valuable in treating cancers in humans.

Sun Powers Hearing Aid

➤ PAPER THIN SLABS of pure silicon are the basis for a new electronic device that promises an inexhaustible power source for hearing aids.

Known as the Acousticon "Sun-Powered" Generator, the device is mounted on the temple bar of eyeglass hearing aids. It is said to be so sensitive that it operates effectively in ordinary daylight and lamplight; in darkness the regular hearing aid battery is automatically turned on.

"Hot Laundry" Saves Gear

➤ GENERAL ELECTRIC technicians at the Hanford atomic plant near Richland, Wash., have saved $90,000 in six months by "washing" equipment formerly discarded as too "hot" to handle. Expensive pumps, centrifuges, etc., that workmen could not approach to repair, are now immersed in boiling chemicals and a 28-foot-deep pool of water, reducing radioactive contamination to safe levels. Savings will increase as new techniques are developed.

Plutonium is a comparatively new element due to the fact that it never occurs in nature.

Synthetic sapphires have found their way into industrial and medical equipment, guided missiles and watches.

The exact site at which insulin acts in the human body — on tissue cells — has been shown for the first time by a new radioisotope test.

Traffic Cops of Oil Refining

Catalysts in the Petroleum Industry

by F. Emerson Ivey, Jr., *Director of Technical Service, Davison Chemical Co., Division of W. R. Grace & Co.*

"Catalysts in the Petroleum Industry" — a more provocative and perhaps equally informative subtitle would be "Traffic Cops and Oil Refining." As we shall see, these two phrases are synonymous, because catalysts are really chemical traffic cops. And most modern petroleum refining processes owe their economy and versatility to the catalysts around which they are designed.

Since catalysts are an important part of today's refinery operations, we shall consider what catalysts are, why they are needed in petroleum refining, how they are used, and the results that are achieved by their use.

Catalysts Defined

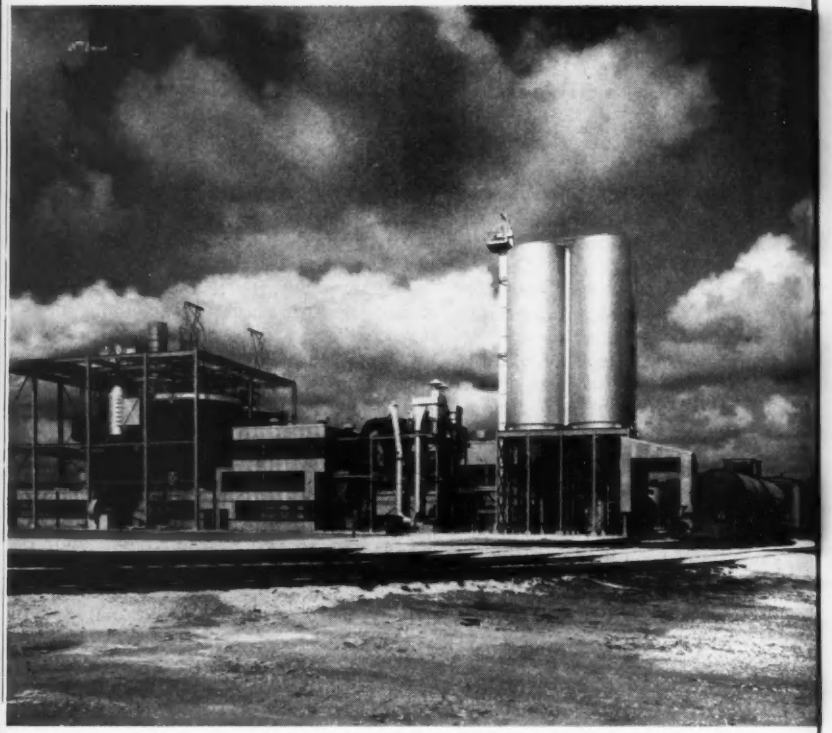
Textbooks define a catalyst as a chemical agent which influences the *rate* of a chemical reaction while remaining unchanged itself. Observe that there is no restriction on the physical form which catalysts may have. They can be gases, liquids, solids; colorless or colored; large or small; hard or soft. And notice too that the definition makes clear by omission what a catalyst *cannot* do—no catalyst can promote or accelerate a chemical reaction which is contrary to the natural laws of chemistry and thermodynamics.

Perhaps you can now see the analogy between catalysts and traffic cops. Just as the policeman can regulate the flow of traffic within the existing network of streets and highways, so can catalysts regulate reaction rates within the limitations imposed by natural laws. Neither one can create new channels. And just as the ideal cop is physically the same after his shift of duty, so the ideal catalyst is unaltered by its service. Needless to say, in practice both end up somewhat the worse for wear.

To understand why catalysts are necessary in modern petroleum refining, we must first appreciate the fundamental nature of the fossil fuel called oil. From the viewpoint of today's automobiles, airplanes and furnaces, crude oil is a mess. When pumped from the ground it is usually a viscous, stinking, dirty conglomeration of hydrocarbon molecules of so many types that one might sometimes wonder if there were any two alike. And if, by dint of man's inventiveness, crude oil is separated by distillation into narrow fractions which attempt to sort out these types of hydrocarbons according to some preconceived idea of usefulness, then one usually finds that there is either too much or too little of that particular fraction to satisfy the demand, or its qualities are atrocious.

Thermal Cracking

When Edwin L. Drake first discovered oil in Titusville, the total value lay in its kerosene content, which was removed by crude distillation. All the rest of the oil was thrown into the rivers until they liter-



➤ A PANORAMIC VIEW *of a catalyst manufacturing building. On the left are Peabody furnaces and spray driers. Next, secondary filter and water-treating area. To the right of that are flash driers, and finally, the finished product silos with rail cars ready to receive the finished product. In far right foreground is the trackmobile used to switch all cars delivering raw materials.*

ally ran black. Then came Henry Ford's automobile and the need for fuel to power it. So gasoline was distilled from the crude oil in addition to kerosene, but still the rivers ran black with wasted oil. As the demand for gasoline reached the point where it began to exceed the quantity contained in crude oil, scientists considered ways for converting the wasted heavier oils into gasoline, and "thermal cracking" was born.

Now "cracking" is a perfectly descriptive term in this application. The boiling range, or "heaviness", of an oil is a function of the size of the hydrocarbon molecules comprising it. For example, gasoline is lower boil-

ing or lighter than lubricating oil, and its chain-like hydrocarbon molecules are much shorter in length than those of lube oil. Hence if one could "crack" the lube oil molecule into several pieces, and at the same time control the size of these pieces, then one could make gasoline from lubricating oil. This is exactly what thermal cracking does.

It was found that if heavy oils were heated in a closed vessel to high temperature, in the order of 1000° F, and subjected to high pressure, perhaps several thousand pounds per square inch, then cracking would occur. Simultaneously, the shape of some of the cracked molecules was changed from their original straight chains to branched chains and even rings. And this change in molecular configuration was found to result in improved resistance to uncontrolled combustion in gasoline engines; in other words, the gasoline produced by thermal cracking had a higher octane number than that of the gasoline distilled directly from crude oil.

Improve Yield and Quality

The addition of thermal cracking to refinery processing therefore not only increased the yield of gasoline per barrel of crude oil, but also improved the gasoline quality. As a result, engineers could work at improving the design of gasoline engines to take advantage of the higher octane values and to translate them into greater power output and improved performance. And of course the ability to convert heavy oils into gasoline did much to eliminate the dreadful waste typified by the black rivers of Pennsylvania in the late 19th century.

So there existed for 20 years a workable balance between the available quantity and quality of gasoline and fuel oils and the demands of a growing country for these products. This balance was violently shattered by the advent of World War II. Suddenly, airplanes in previously undreamed of numbers were demanding huge quantities of gasoline of an octane quality which could not then be commercially produced. But fortunately scientific development had again anticipated the need.

The Houdry Process

As early as 1928, a Frenchman named Eugene Houdry had realized that there were important weaknesses in thermal cracking, and had set out to do something about them.

First, the high temperatures and pressures required for thermal cracking dictated that the refining units be built of extremely thick-walled, heavy components of special steels. Even so, dangerous explosions and fires were not uncommon.

Second, it was difficult to direct the cracking reactions toward only desirable products. In addition to gasoline, large quantities of unwanted coke and gas were also produced.

And thirdly, it was foreseeable that the octane level of thermally cracked gasoline would eventually be below that required by more modern engines.

Houdry also understood the function of catalysts to control reaction rates. So he undertook to change cracking into a catalytic process. Fortunately he succeeded, and in 1936 the Sun Oil Company, which had brought Houdry to the United States, announced the first catalytic cracking process.

The catalyst which Houdry de-

veloped for the cracking of petroleum was composed of two very common minerals, silica and alumina, synthetically combined into a white compound, and physically formed into pills. It is insoluble in water, oil or mineral solvents; chemically very stable; and completely non-toxic. In addition, it has one very unique and essential property. Each pellet is very porous, or sponge-like, so that oil vapors can penetrate to the very center. Hence, each pellet presents a very large surface area on which the cracking reactions can be promoted.

Because of the activity of the catalyst, Houdry's catalytic cracking process operated at atmospheric pressure and around 800-900° F temperature. This permitted a dramatic improvement in the design of commercial cracking units. But of more importance to a nation at war was the fact that the yield and the octane number of the gasoline were higher than those from thermal cracking. So early military aircraft had acceptable fuel. But as their number grew, even the Houdry process was unable to keep up with the demand. This was because the Houdry process had several inherent limitations.

Weaknesses of the Process

The Houdry process operated by vaporizing heavy oils and passing these vapors through a vessel or reactor which contained a fixed bed of catalyst pellets. Because of certain mechanical aspects of the reactor design, it was essential that the oil to be cracked be entirely vaporized. Now this fact limited the boiling range of acceptable charge stock. If the charge stock was too heavy, or high boiling, then the temperature required to vaporize it would cause some thermal

▶ W. R. GRACE & CO., *Davison Chemical Division, pellets resembling those used in reforming units.*

cracking, with the formation of coke which would plug up parts of the unit and force a shut-down. So the Houdry process required very clean charge stocks having a relatively low boiling range, say 400° F to 750° F, and the availability of such stocks was limited.

A second weakness of the Houdry process was the way in which it was forced to compensate for the imperfect nature of the catalyst. Although a catalyst is theoretically unaffected by use, this is seldom the case in practice. During the cracking reaction, the catalyst becomes covered with a heavy black solid called coke, which gradually suppresses its cracking activity until it is very low. This required interruption of the oil flow to the reactor so that the coke could be removed from the catalyst by controlled burning with air. As a result, a reactor was engaged in useful

cracking only about one-third of the time.

Other Processes Developed

Fortunately, other people had foreseen the effects of these limitations in the Houdry process, and had undertaken the development of other types of catalytic cracking processes. Two of these newer catalytic processes, the Fluid and the Thermofor Process, had as their basis a common conception. It was visualized that if the catalyst could be moved between two vessels, then one of them could be specifically designed for the cracking reaction and the other for regeneration of the catalyst by burning off the deposited coke. Thus the operation of the unit would be continuous and each of the two necessary steps of reaction and regeneration could be carried out with maximum efficiency.

The Thermofor Catalytic Cracking Process which was developed jointly by Socony-Vacuum, Sun Oil and the Houdry Process Corporation, elected to stay with the pelleted Houdry catalyst. To transfer catalyst between the reactor and regenerator, gravity was used for downward flow, and bucket-type elevators for upward lifts. These bucket elevators were quite similar to the type frequently seen on construction jobs for loading dirt into trucks.

The big difference was that these elevators had to operate at the temperature of the unit, which varied between 900 and 100° F. I think you can imagine the mechanical problems which was created. Elevator failure was stoically tolerated, and maintenance costs were high. In addition, there was the problem of removal of heat from the bed of catalyst pellets in the regenerator. The burning of coke releases huge quantities of heat which must be rapidly removed or the catalyst will be damaged. So the Thermofor regenerator contained a large number of tubes through which water flowed. Heat from the catalyst falling downward around these tubes was transferred to the water and generated steam. But the abrasive action of the catalyst often wore holes in these tubes, and if enough of the tubes were punctured, a shut-down for repairs was unavoidable.

"Fluid" Catalysts

Simultaneously with the development of the Thermofor process, the Standard Oil Company of New Jersey, Shell Oil and others were working on the so-called Fluid Process. This name is derived from a rather unusual property of the catalyst. Although the catalyst is essentially the same silica-alumina compound as the Houdry and Thermofor catalysts, it is produced as a very fine powder whose particles are, on the average, only 2-ten thousandths of an inch in diameter. It was found that when such a fine powder is dispersed in a gas, it takes on many of the properties of a liquid. so the engineers took advantage of this fluid property of the catalyst and designed a plant so that the catalyst would literally be blown from the reactor into the regenerator by the air which would burn off the coke, and then would be blown back into the reactor by the vaporized oil which it was to crack. Furthermore, the turbulence of the boiling action of the catalyst in the vessels served to distribute heat and to transfer it directly into the various gases. Thus, by the mechanism of the new-found fluidized solids technique, some of

the mechanical weaknesses of the early Thermofor Process were overcome.

Of course, the Fluid Process is not without its problems. Holding such a fine powder in the unit requires special types of equipment which can fail. And when it does, black coke-laden catalyst can be blown over the landscape by the ton. Perhaps you can recall incidents of this kind in East Baltimore several years ago. The newspapers made quite an issue of them.

The Fluid Catalytic Process has been by far the most successful of them all. Over 100 units are in operation in the United States alone, and they crack nearly 3,000,000 barrels of oil daily.

Baltimore, Md., has a unique spot in this development. The world's first commercial plant for producing fluid cracking catalyst began operation in 1942 in the Curtis Bay (Baltimore) Plant of the Davison Chemical Company. And it remained in continuous production until just last year when it was replaced by a more versatile and efficient installation. During the intervening years, Davison also built fluid catalyst plants in Cincinnati, Ohio; Lake Charles, Louisiana; Warrington, England; and Valleyfield, Quebec, to become the world's largest catalyst producer.

Today, four companies in the United States produce nearly 400 tons per day of fluid cracking catalyst at a total value of around $40,000,000 per year. And Thermofor units account for an additional several hundred tons per day of pelleted cracking catalyst. So you can see that the production of cracking catalyst has become a major industry.

Catalysts in War and Peace

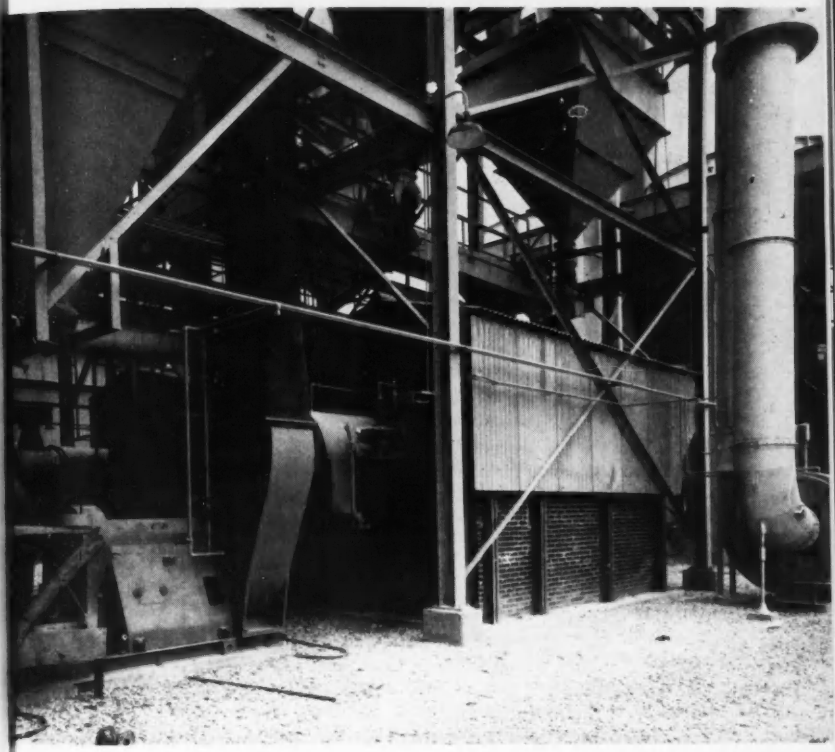
The various catalytic cracking processes which we have discussed carried the major part of the tremendous burden of fueling the military aircraft of the Allied Forces in World War II. It is a matter of record that they were adequate for the job.

As the United States economy returned to peace-time status, the pent-up demand of the American people for new automobiles created a demand for gasoline which soon taxed even the war-time capacity of the petroleum industry. And of course, Detroit had its own techniques for making certain that the boom would not die an early death. Engineers labored over drawing boards to design more and more power into automobile engines, while salesmen worked equally hard at convincing the public that this was exactly what was wanted and needed. Both groups succeeded to an amazing extent, and the horsepower race was on.

Of course, Detroit's success merely put the monkey on someone else's back, for the increases in engine horsepower demanded corresponding increases in gasoline octane ratings. In fact, there was a period during which the octane demand of some engines exceeded the octane producing ability of refiners. Out of this kind of pressure, catalytic reforming was born.

Catalytic Reforming

The term "catalytic reforming" is just as descriptive as "catalytic cracking." You will recall that the octane number of gasoline produced by catalytic cracking is far above that of virgin gasoline distilled from crude oil. If, then, a gasoline which is a blend of catalytically cracked and



➤ Lake Charles, La., *petroleum catalyst cracking plant Raymond flash drier used in the manufacture of synthetic petroleum cracking catalysts.*

virgin gasolines has too low an octane value to satisfy engine requirements, the blend can be improved by raising the octane level of its virgin gasoline fraction. But since the virgin gasoline is already of the correct boiling range and molecular size, improvement in octane rating cannot be achieved by cracking, but must be obtained through rearrangement or reforming of the structure of its molecules.

As mentioned earlier, it was known that the octane ratings of various gasoline-type hydrocarbons depend upon the actual shape or configuration of the molecules. The straight chain-like molecules of the virgin gasoline are the poorest in octane rating, while branched chains or ring structures are superior. Hence the job of a re-

forming process and catalyst is to rearrange or reform straight chain molecules into branched chains and rings without destroying them by cracking.

Numerous competitive catalytic reforming processes have been developed in the last decade. With a single exception, all the processes have two common denominators: they use pelleted catalysts in a fixed bed reactor, and their catalysts contain platinum as the active component. The platinum gives the catalyst a light gray appearance.

Simpler Than Cracking

The operation of a catalytic reformer is a rather simple process compared to that of catalytic crackers. This is because the catalysts are so selective in the reactions which they promote that the production of interfering coke on the catalyst is minimized. Hence frequent regeneration is unnecessary, and a single reactor can be kept in operation for extended periods of time.

The use of a precious metal in large quantities for a commercial process has created some unique and interesting problems. To give you some idea of the magnitude involved, it is estimated that at the present time about 350,000 troy ounces of platinum worth around $34,000,000 are tied up in the reactors of reforming units in the United States alone. This is far more platinum than existed in the entire world less than 10 years ago. As more and more reforming units were built in the mid-1950's, a shortage of platinum developed which resulted in violent increases in the open market platinum price. In several years, the price per troy ounce climbed from around $70 to $110, and jewelers were hard-pressed to find sufficient platinum for their needs.

The advertising agencies of the oil companies had a field day when the new reformed gasolines reached the pumps. Not only was there much boasting about the higher octane ratings, but such catch phrases as "made with platinum" were everywhere in evidence. One company went so far as to claim that its gasoline actually contained platinum, but since this was true only to the extent that microscopic particles of catalyst might accidentally end up in the product, the exaggeration was fortunately discontinued.

$10 Million in Platinum

And just imagine the problems of the companies engaged in converting these large quantities of precious metal into catalyst! For example, the Curtis Bay Plant of Davison handled in the neighborhood of $10,000,000 worth of platinum last year. This required special security precautions, such as the storing of platinum inventories in the vaults of a city bank, and elaborate check-out systems to assure that all platinum would end up as catalyst.

And the processes for converting the platinum into catalyst are most elaborate, for physical loss must be reduced to a level which is usually considered impractical in commercial processing. A leaky valve could result in thousands of dollars worth of platinum flowing to sewer, or dusting would literally result in dollars floating away on the breeze. Hence, the building housing the plant is sealed, and periodically vacuum-cleaned, including the steel beams

and equipment, so that the platinum can be recovered from the dust.

While it would not be true to attribute today's super-premium gasolines of over 100 octane number to catalytic reforming alone, it is no exaggeration to say that these fuels would be impossible without catalytic cracking and catalytic reforming.

The production of gasoline is not the only use which modern refineries have for catalysts. The American public has become dependent upon other conveniences besides automobiles. Millions of homes are now heated with fuel oil, and competition between oil-fired and gas-fired furnaces has become keen. So a process called Hydrodesulfurization was developed for treating furnace oils to improve their odor and burning qualities. This process requires a special type of catalyst. Its blue color indicates something of the chemical composition of the active ingredients, which are nickel, cobalt and molybdenum. This catalyst can also be used to improve the quality of lubricating oils.

Refiners have come a long way since the "black river" days. Intense effort is now made to utilize every ounce of the petroleum barrel, both for economic reasons and the need to minimize the pollution of air and water. The light gases which occur in crude oil, or which are produced in cracking reactions, have become building blocks for the creation of valuable products not normally associated with the oil industry.

Rubber From Gas

By the use of this pelleted green catalyst, a gas called butane can be transformed, by removing hydrogen atoms, into another gas called butadiene. Butadiene is a raw material for several of the synthetic rubbers which predominate today's market.

A yellow powder is another catalyst which has recently been developed to produce an entirely new family of polyethylene plastics. You may have noticed that your clothes are now returned from the cleaners in plastic bags, and potatoes and apples appear in the store already packaged in transparent plastic bags. This plastic is polyethylene, and it owes its existence to this catalyst.

We have discussed, not all, but some of the catalysts used by the petroleum industry. Of course they vary in color, in pellet size, in physical form. They also differ widely in cost, from a low of $0.15 per pound to a high of $12 per pound. But this one thing they have in common: they all make possible the production of consumer goods of a quality and at a cost which is unique in history. Our modern living standards depend in great measure upon these chemical traffic cops.

Wider use of research-developed chemicals from gum turpentine as catalysts in the production of polymeric materials, including synthetic rubber, is in prospect.

About 10,000,000 Soviet students are currently studying English in grammar school, high school, and college; only 4,000 Americans are learning Russian, all of them at the college level.

Book Condensations

MODERN CHEMISTRY — Charles E. Dull, H. Clark Metcalfe and John E. Williams — *Holt,* rev. ed., 696 p., illus., $4.96. A high school textbook, each unit followed by more difficult exercises: "Check Your Progress in Chemistry" and "Challenging Your Knowledge."

HOW TO SOLVE CHEMISTRY PROBLEMS — C. H. Sorum — *Prentice-Hall,* 2nd ed., 184 p., paper, $2.25. A self-teaching review of first-year college chemistry principles, with problems, solutions, and answers.

A TREASURY OF SCIENCE — Harlow Shapley, Samuel Rapport and Helen Wright, Eds. — *Harper,* 4th rev. ed., 776 p., $6.95. New material on Radio Astronomy, Measurement of Geologic Time, The Origin of Life and Man's Ancestral Past. New sections on Rocketry and Space Travel, and Atomic Energy.

MODERN CHEMICAL PROCESSES: A Series of Articles Describing Chemical Manufacturing Plants — Walter J. Murphy, and others, Eds. — *Reinhold,* 154 p., illus., $5. By the editors of *Industrial and Engineering Chemistry* (see CHEM., this issue, p. 26) together with the technical staffs of the cooperating organizations.

FUNDAMENTALS OF CHEMICAL ENGINEERING OPERATIONS — Maurice G. Larian — *Prentice-Hall,* 644 p., illus., $10.50. This undergraduate text emphasises the analytical training of the engineering student.

CHEMICAL ENGINEERING PRACTICE, Vol. 4: Fluid State — Herbert W. Cramer and Trefor Davies, Eds. — *Academic,* 642 p., $17.50. Thermodynamics of physical systems.

FUNDAMENTALS OF THERMODYNAMICS — Carroll M. Leonard — *Prentice-Hall,* 376 p., illus., $8. An introductory course with special application to power plants, refrigeration, air conditioning, heat transfer and flow of fluids.

SCIENCE STUDENTS' GUIDE TO THE GERMAN LANGUAGE — A. F. Cunningham — *Oxford Univ. Press,* 186 p., $2. An experienced teacher's method, using current scientific reading matter.

HEAT EXCHANGERS: Applications to Gas Turbines — W. Hryniszak — *Academic,* 343 p., illus., $10. Deals not only with the factors affecting the performance of the heat engine, but also their effect on the design and cost of other engine components.

CHOLESTEROL: Chemistry, Biochemistry, and Pathology — Robert P. Cook, Ed. — *Academic,* 542 p., illus., $15. For scientific workers in the field, it covers representative work, includes references and appendix of laboratory methods.

SEPARATION AND PURIFICATION OF MATERIALS — Rolt Hammond — *Philosophical Lib.,* 327 p., illus., $10. Covers solid-solid, solid-liquid, solid gas, liquid-liquid and gas-gas systems with chapter on separation and purification in nuclear engineering.

PARTICLE EMISSION: Proceedings of the Symposium on Air Pollution held October 21, 1957, at The Franklin Institute in Philadelphia — F. E. DeMartini and others — *Journal of the Franklin Institute,* Monograph No. 4, 105 p., illus., paper, $3.

Review of the Project
Sherwood Report

The Control of H-Bomb Power

by ANN EWING

▶ A FULL-SCALE, power-producing plant harnessing the awesome fury of hydrogen bombs for peaceful purposes may be built within the next 10 or 20 years.

Only "ingenuity, hard work and a sprinkling of good luck" is needed to obtain controlled fusion power, a book-length report on "Project Sherwood" has just revealed.

Project Sherwood is the name given to the U. S. program aimed at controlling thermonuclear reactions to produce power. (See CHEM., Feb., 1958, p. 1.) The first detailed account of the program's successes and failures is now available to the public as part of the U. S. participation in the second international Atoms for Peace Conference in Geneva.

The official fusion story has been likened to the famous Smyth Report of 1945, which outlined the development of the atomic bomb to the public for the first time. The controlled thermonuclear report is less technical because the methods are more difficult to describe without using mathematical equations.

Because of the enormity of the problems involved, progress in harnessing fusion reactions for power may be "slow and halting." There, however, is "no basic obstacle" yet uncovered to prevent attainment of the final goal, Dr. Amasa S. Bishop, who prepared the report for the Atomic Energy Commission, concluded.

Successful completion of the program, "one of the most important and challenging" ever undertaken, would yield a new and practical source of energy to meet man's energy needs for "as far into the future as he can see" since the deuterium (heavy water) fuel to be used can be obtained in virtually unlimited supply from the world's oceans.

Fusion is the combination of certain very light nuclei (the cores of atoms) into heavier components with a tremendous release of energy. It is the opposite of fission, as in atomic bombs and atomic power plants, where the energy is released by the splitting of atoms.

To control thermonuclear energy, the deuterium of deuterium-tritium fuel must be ionized and heated to a temperature of a hundred million degrees centigrade or more and the resulting plasma confined at this temperature long enough to allow a substantial portion of the nuclei to fuse. The energy thus released must then be harnessed and converted to usable power.

At the extremely high temperatures required for fusion, the atoms are entirely stripped of their electrons. The result is a wholly ionized gas, or plasma, consisting of charged nuclei and electrons in rapid motion. Although the whole is electrically neutral, the plasma can conduct electricity.

Three basic methods, each with many variations, are being tested as

ways of plasma confinement in the four main laboratories and other institutions conducting thermonuclear research. They are pinch-type, stellarator-type and magnetic mirror confinement.

Two promising other approaches are the molecular ion injection method and the Astron concept in which a circular sheath of high-energy electrons acts to confine and heat the plasma.

In the seven years since Project Sherwood was initiated, plasma temperatures of a million degrees, more than 30 times higher than those reached previously, have been obtained.

One device, known as Scylla and built by the Los Alamos Scientific Laboratory, has yielded a rather intense burst of neutrons, the neutral particles found in atomic cores whose production is an important measure of fusion reactions. Although the exact origin of the neutrons has not been determined, there is as yet no disproof of their thermonuclear origin.

The scientific team at Los Alamos, under the direction of Dr. J. L. Tuck, is concentrating its efforts for the most part on the pinch approach, in which the plasma is pinched into a narrow stream away from the container walls due to its own magnetic field.

At Princeton University a staff of scientists and engineers, including some from industry, is building several models of a stellarator, the largest of which should achieve 100 million degree temperatures for experimental purposes. The stellarator approach, proposed by Dr. Lyman Spitzer, Jr., director of Princeton University Observatory, consists of confining the plasma in an endless tube by means of an externally imposed axial magnetic field.

In the magnetic mirror approach, which is being tested along with others at the University of California's Radiation Laboratory, plasma confinement is provided in a straight cylindrical tube by means of an externally composed axial magnetic field with mirrors at the two ends.

In the molecular ion approach being investigated at Oak Ridge (Tenn.) National Laboratory, deuterium ions are injected transversely into a static magnetic field and dissociated by a special carbon arc. This method of plasma ignition to very high temperatures, if successful, should also be useful for other approaches, such as the stellarator.

New York University, the Naval Research Laboratory and Massachusetts Institute of Technology are also investigating various aspects of controlling thermonuclear research. The over-all coordination and administration of the entire program is under the direction of Dr. A. E. Ruark of the Atomic Energy Commission.

A low molecular-weight protein containing 2.2% cadmium has been isolated from the cortex of the horse kidney.

A new antibiotic, ristocetin, that kills disease-causing bacteria outright instead of merely halting their growth has been developed.

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